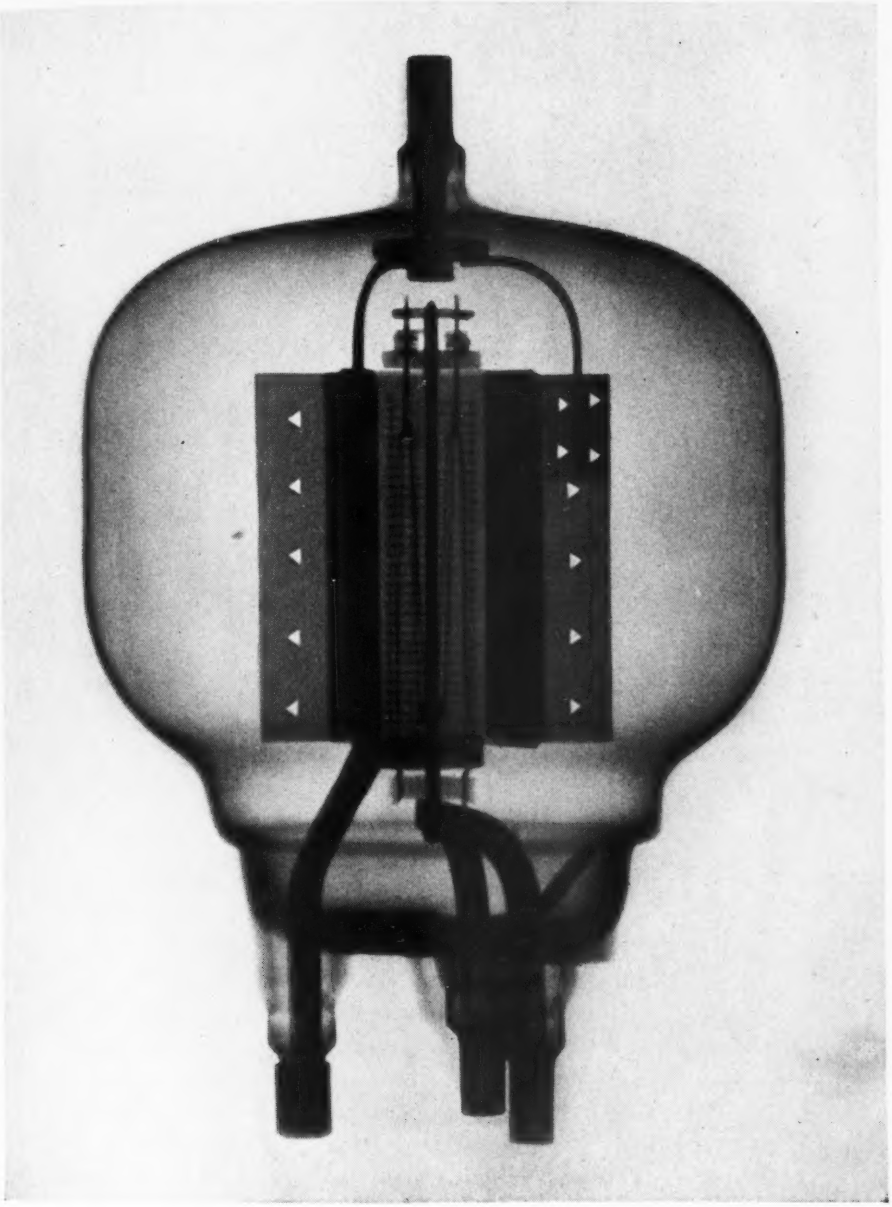
# BELL LABORATORIES RECORD

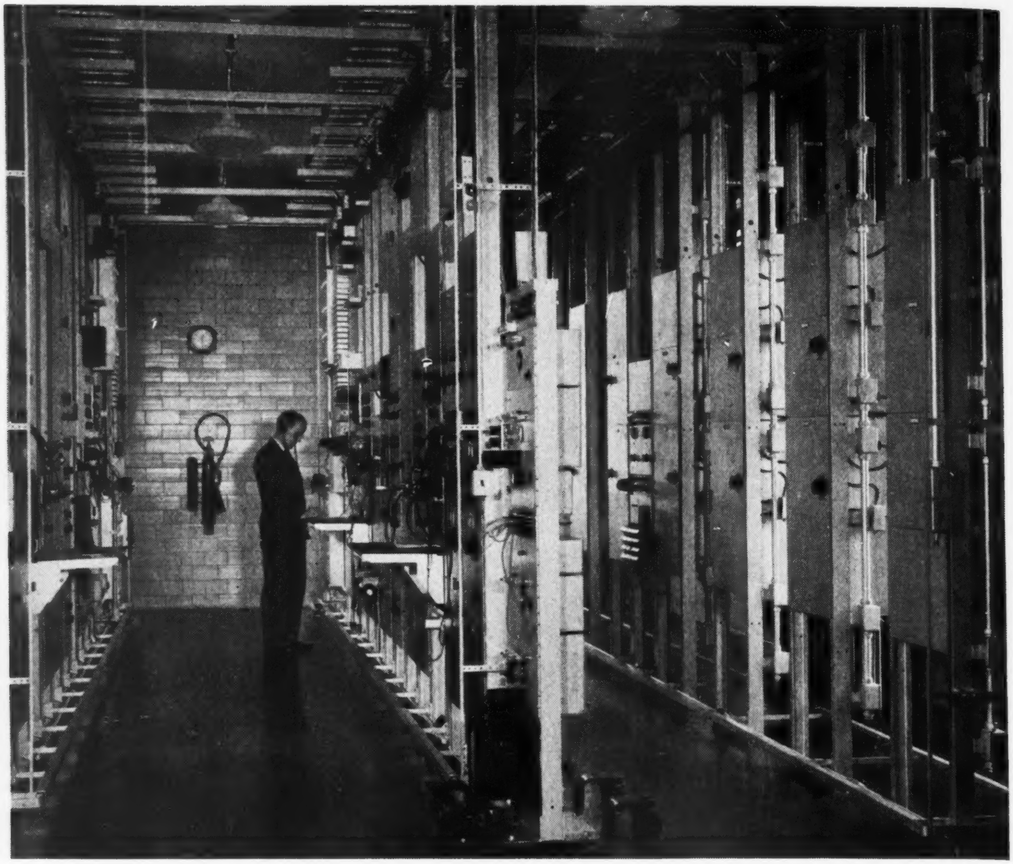


JANUARY
1940

VOLUME XVIII

NUMBER V

*X-Ray photograph of the Western Electric 357A high-frequency power tube*



# The Manahawkin Musa

By A. A. OSWALD
*Radio Development Engineer*

IN MAY of 1939 the American Telephone and Telegraph Company began using a multiple-unit steerable antenna system, called a musa, in its London service. It is located at Manahawkin, New Jersey, about forty miles south of Asbury Park. The site is a salt marsh and remarkably flat; the deviations in the general trend of the ground are only of the order of six inches. Flat ground of high conductivity is very favorable to musa reception, and it was largely these characteristics that led to the selection of this particular location.

The musa is a multiple-unit antenna whose vertical angle of reception may be controlled over a considerable range. Its advantages in reducing noise have already been discussed* in connection with the experimental model at Holmdel. From this, however, the commercial musa differs considerably. It employs sixteen rhombic units, each 180 meters long, and occupies a space nearly two miles long in the direction of the great-circle path to Rugby, England. In addition, this installation is designed for auto-

*RECORD, *June*, 1938, *p.* 148.

matic operation, and also for single-sideband* reduced-carrier reception.

Two complete receivers are provided, each capable of operating on any one of five frequency assignments. The frequency of either receiver may be changed quickly by switching the input filters ahead of the first detectors, and by changing the frequency of the beating oscillators. Each receiver provides simultaneous reception at three vertical angles independently adjustable. Since the time of transmission will be different over the three paths, delay equalizers are employed, but both the delay and angle adjustments are automatic.

Since the advantages of the musa are secured by combining signals from the sixteen component antennas in correct phase relationship, it is obvious that one of the important features of the design is the accurate control of phases. This problem divides into two parts: first, the precise shifting of the phases to control the direction of reception; and, second, the careful control of all the fixed phase shifts that are introduced by the circuit elements. This is a matter largely of duplicating and maintaining the same phase shift in each of the sixteen circuit elements ahead of the phase shifters, and in each of the four branches of each receiver behind the phase shifters. If extremely close limits were not established for the individual parts, the introduction of replacement units manufactured at some later time would require lengthy and cumbersome "line-up" procedures. In general the deviations are held to $\pm 1$ degree at twenty megacycles, although for a few elements $\pm 3$ degrees is permitted. From antenna to phase shifters the system includes about fifteen sources of phase shift, and the overall deviation is held to $\pm 10$ degrees. Credit is due to the design groups of the Apparatus Development Department for meeting the close requirements set on transformers, filters, and various elements of the delay circuits.

Each antenna is connected to the receiver through a coaxial transmission line. About eight miles less of transmission line was used by placing the receiver building near the middle of the antenna array. This introduced, however, an additional phasing problem. With the receivers at the end of the array, as in the experimental

*Fig. 1—The line patching panel is in the middle of the first row of bays, which comprises the input filters and first detectors*

*Record, *November*, 1939, *p.* 84.

musa, there is a regularly increasing time of arrival of the radio wave at the successive antennas, and a regularly decreasing time of transmission over the coaxial line. With the station near the middle of the array, the decrease in time of transmission over the coaxial line changes to an increase for antennas beyond the receiver station. This was taken care of by placing differential gears between the shafts that drive the phase shifters for the front and rear groups of antennas. The arrangement is satisfactory for a band width of about 40 kc; but a shift in the differential setting is required when a change is made to another frequency assignment.

Exclusive of the power plants and wire-terminal apparatus, the two receivers occupy thirty-seven bays arranged in three rows as shown in the photograph at the head of this article. The first row at the right contains the input filters and first detectors for both receivers, while the other two rows comprise the rest of the equipment, each row including the equipment for one of the receivers. The middle bay of the first row includes the coaxial jack panel, at which the transmission lines from all the antenna units are terminated. This bay is shown in Figure 1. From here, lines exactly equal in length run to the input circuits of the sixteen first detectors for each receiver. These are also fed from the first beating oscillators by equal-length lines. The outputs of the detectors are brought back to another jack panel on the same bay, and there patched—again through equal-length lines — to the intermediate-frequency amplifiers and phase shifters. These are located at the ends of the receiver rows as shown in Figure 2.

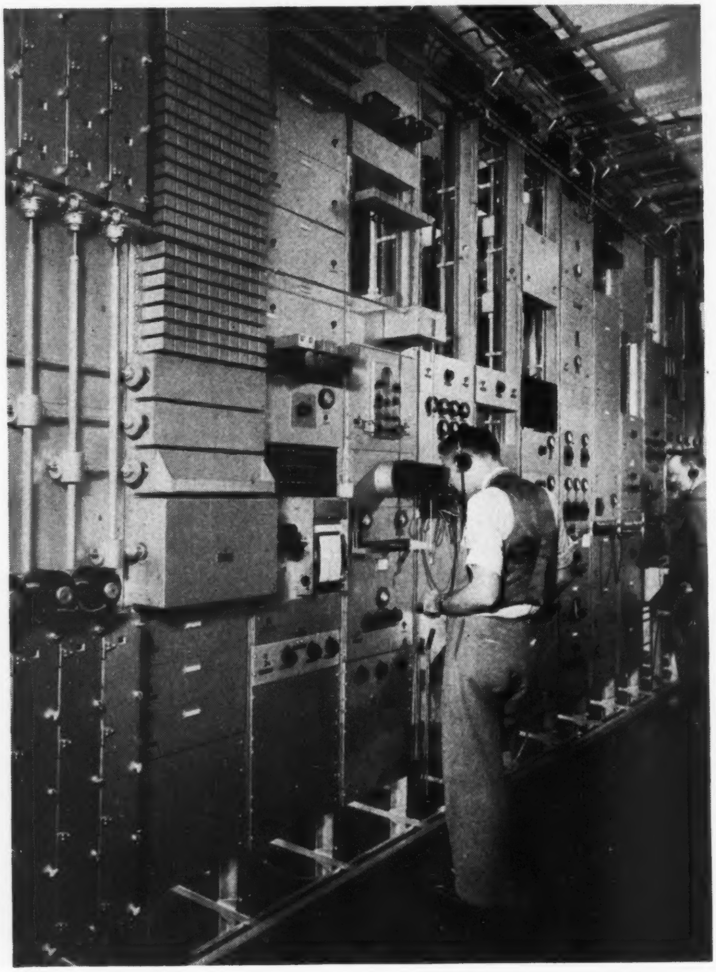


*Fig. 2—The drive for the phase-shifting system is near one end of the receiver row*

Each receiver has four sets of phase shifters, one for each of the angles of reception, and one used with

a monitoring circuit that measures the reception at various angles and automatically adjusts the other three phase shifters for reception at the angles of the most prominent signals. The complete angular range over which the musa operates is divided into forty-four sections, and as the monitor channel is swept over the entire range, it integrates the energy received over each section. The section receiving the largest average energy indicates the angle for maximum reception. Relays then cause the motor driving the phase shifters of one of the main branches to select this angle. Since reception is provided for three angles simultaneously, the forty-four sections are divided into three groups, each of which will control the angle of reception for one of the three main branches. A recorder, shown in Figure 3, registers the signal strength throughout the received range, and the angular limits of the three branches—which may be adjusted manually—are changed from time to time to suit the received pattern of the signals.

The first beating oscillators are adjusted so that the carrier output of the first detectors is always at 2900 kc, and the rest of the system is designed for operation at fixed frequencies. The output of each group of phase shifters is amplified and applied to the second detectors, which reduce the carrier frequency to 100 kc. From this point each branch has the same apparatus as the single-sideband receiver recently described in the RECORD.* The carrier and sideband travel separate paths for each branch; and the same phase change must be maintained for each branch throughout the range of the automatic volume control. Also, the gain-bias characteristics of the corresponding tubes in the three branches must be the same within close limits, because the automatic volume controls for the three branches are interconnected and the gain must be the same in all branches.

*Fig. 3—W. T. Wintringham examining the record of the angles of arrival of the signals*

Since the outputs of the three branches are combined, it is necessary that they be in phase at the point of combination. The transmission time, however, varies with the angle of reception—that for the highest angle being the longest. Delay networks must therefore be inserted in the other two branches to make the delay of all three the same. Since the amount of delay required will vary from moment to moment, automatic control of the delay networks is provided. Signals in the two lower branches are compared with those in the high-angle branch in special mod-

*loc. cit.

ulator circuits sensitive to phase differences, and relays are operated which cause motors to insert the correct amount of delay.

With this type of delay compensation, it is essential to use reconditioned carrier, since the carrier received at each angle must be used at the third detectors to demodulate the sideband received at that angle. If this were not done, the audio phase relations at the branch outputs would be random, and consequently could not be corrected by the delay.

At times, however, the transmission conditions are such that the reconditioned carrier is less satisfactory than carrier from a local source, which is free from noise and constant in amplitude. A second method of operation, known as branch selection, has also been provided at Manahawkin. It employs a local carrier and a system of modulators and relays that compare the speech volumes in the three branches differentially, and then connect the line to the branch that has the highest value at that moment.

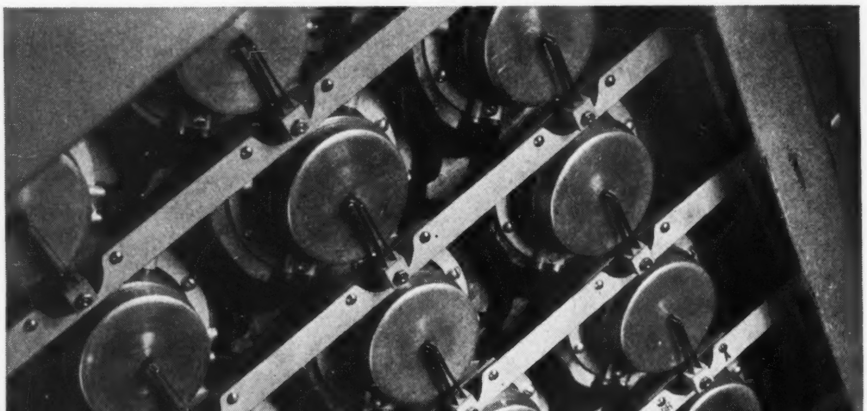
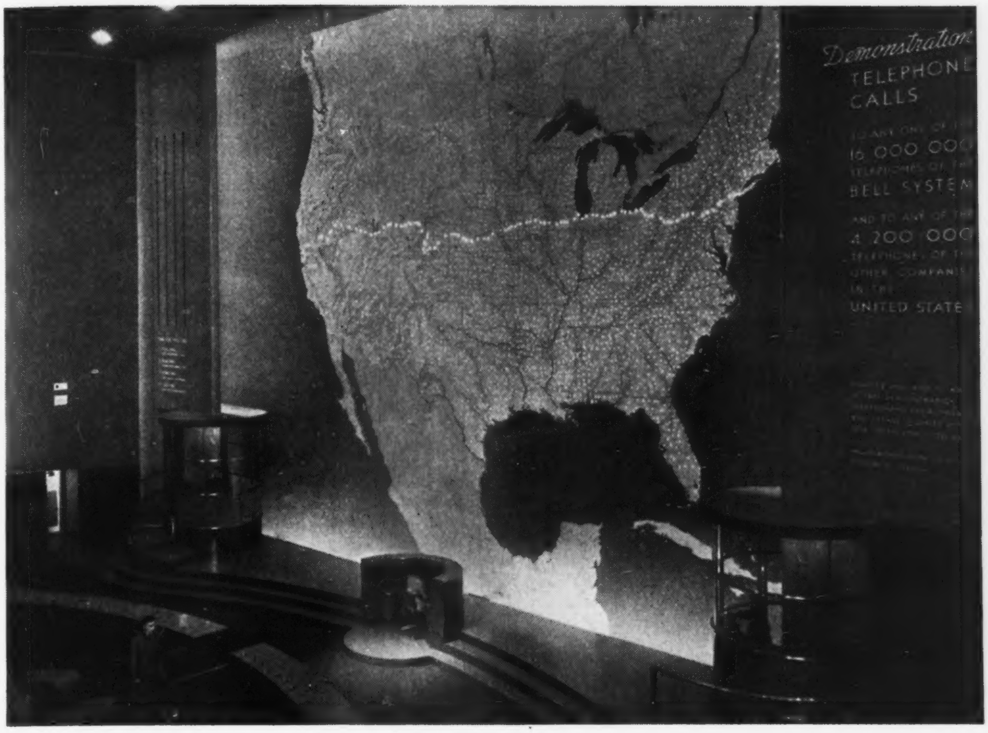


*Fig. 4—Bottom group of phase shifters of a musa receiver*



# Equipment for the Demonstration Toll Call

By L. P. BARTHELD
*Special Equipment Engineering*

"THE best fun in town is over at the Fair's A. T. & T. Exhibit where, to date, an estimated 100,000 persons have gratified a latent human desire to eavesdrop on the telephone." This comment by Frederick Woltman in the *New York World-Telegram* for May 5, 1939, referred to the Long-Distance Telephone demonstration, which enabled visitors to the Bell System exhibit at the New York World's Fair to listen while others talked by long-distance telephone with friends or relatives any place in the United States. During the call, some 260 other visitors to the exhibit listen—hearing the operator set up the connection and both sides of the conversation. To prevent anything being said that the talkers would not want overheard, the distant talker is notified that it is a demonstration call and that people are listening. At the close of the season it was estimated that a million and a half people had listened to the toll calls, and over 25,000 had talked.

In the demonstration room, on a panel fifty feet high, is a huge map of the United States showing its chief lakes, streams, and mountain ranges. State boundaries are shown, and the positions of 3500 cities and towns are indicated by small glowing switch-

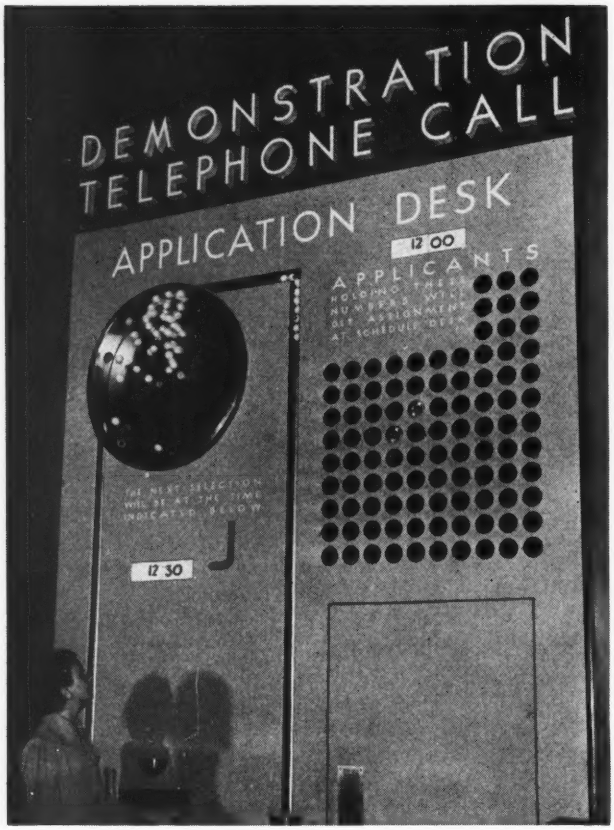



*Fig. 1—Display panel for selecting numbers at the application desk*

board lamps. At each side are circular glass telephone booths. While a conversation is in progress from one booth, a visitor is preparing in the other for the next call.

In front of the map is a semi-circular map-control board. Its operator controls the keys that increase the brilliancy of the map lights along the route followed by the call. This operator also causes the name of the called town and its state to appear in lighted letters near the route terminal. Farther from the map, and running across the entire hall, is a serpentine-shaped counter on which are the receivers with which the visitors listen. Seven smaller counters with receivers are arranged in front of this main counter. An assignment desk near the center, and an application desk at the extreme right—shown in Figure 1—complete the major external features of the exhibit.

A visitor wishing to place a long-distance call fills out a card at the application desk. This card is stamped with a number by the attendant and at intervals of twenty or thirty minutes certain of the numbers are selected. This is accomplished by allowing an air stream to whirl numbered ping-pong balls around in a glass-front container until some half-dozen of them have collected in the glass tube at the right, shown in Figure 1. The winning numbers are then lighted on a display board, and the holders of the cards with these numbers go to the assignment desk. Here they fill another card, giving the name and telephone number of the person with whom they wish to speak. If they do not know the number, they can call "information" with a telephone available here. This card is then given a serial number for the call, and the applicant is conducted to a seat inside of the

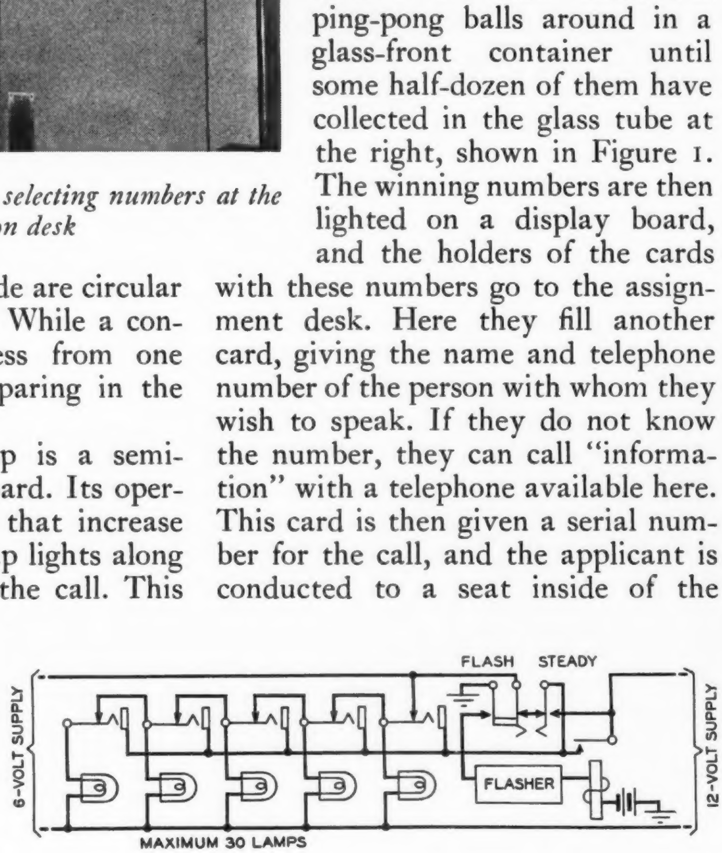



*Fig. 2—Schematic of circuit used for controlling "route" lamps lighted by either a six-volt or twelve-volt supply*

serpentine counter to await his turn.

As each call is finished, the next number is displayed on the side wall. The holder of this number is escorted to the booth just vacated, and given instructions that a green lamp will light in front of him when he is to begin. He is then to lift his handset and, when the long-distance operator answers, give the number he wants in the usual manner. As the toll operator starts to set up the connection, the map operator at the map control operates keys and inserts plugs to light the route across the map, and the state and city names. In the meantime the timing lights at the left indicate the duration of the various operating intervals. At the completion of the demonstration call, the talker hangs up his telephone and all lights are restored to normal.

*Fig. 3—Inserting a stencil for a town in Illinois at the rear of the map used for the toll-call demonstration at the New York World's Fair*

The design of circuits to light the route lamps on the map and to display the name of the city and state was not a simple matter. Lamps on the map are arranged in chain circuits according to the various toll routes. The city lamps along the toll route to Chicago, for example, would be such a chain. Corresponding to each lamp, there is a jack at the map switchboard in the circuit arrangement typified by Figure 2. With no plugs inserted in the jacks, the lamps will all be on the six-volt supply and thus glowing at reduced brilliancy. When a plug is inserted in a jack, and the key operated to the "steady" position, all lamps to the left are transferred to the twelve-volt battery and thus burn at full

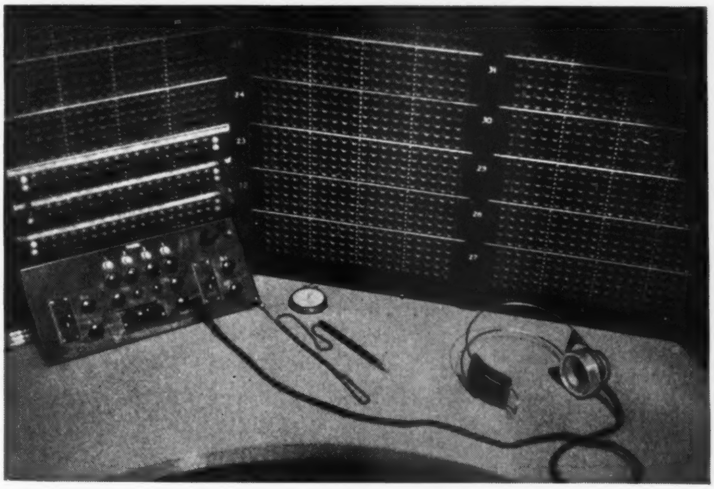


*Fig. 4—Close-up of the map-control board showing state plugs and key panel at left*

brilliancy while the others remain less brilliant on the six-volt supply.

Circuits of this type are provided for the main toll routes leaving New York, for the secondary branch routes leaving the main toll centers, for tertiary routes branching from the secondary routes, and for quaternary routes branching from towns on the tertiary routes. If the call is to a main toll center, like Chicago, the operator, by inserting a plug in the Chicago jack, can bring to full brilliancy all lamps along the route between New York and Chicago. If it were to some city in Wisconsin reached through a branch line from Chicago, a plug is inserted in the Chicago jack and also one in the jack of the town of the proper branch circuit. For a town on a tertiary route, a third plug is used, and for one on a quaternary route, a fourth plug is used.

*Fig. 5—Making a transmission test on one of the repeaters used for the demonstration toll call at the New York World's Fair. Three circuits are available: one in use, and two serving as spares. Each circuit has a repeater and a group of associated equipment. In addition there is a bridging amplifier that is used to supply the receivers for the visitors to the exhibit*

As the number is given to the toll operator, the listening map operator plugs into the required jacks and operates the key which lights the route. When ringing begins, she operates the key to its "flash" position and these lamps flash eighty times a minute. When the distant subscriber answers, the key is again moved to the "steady" position.

On the back of the map is a lamp box for each state with a stencil carrying the state name, and space for another stencil to carry the town name. When these lamps are lighted, the names shine plainly through the map. Before a call is placed, an attendant in the rear of the map, notified of the town to be called, cuts a stencil for it and inserts it in the proper state box, as shown in Figure 3. Besides the jacks for each town on the map-control switchboard, there is another group with a jack for each state. When the call is placed, the map operator also inserts a plug-ended cord into the proper state jack, and thus lights both state and the city names.

A close-up of the map operator's position is shown in Figure 4. The small sloping panel at the lower left carries the key for lighting and flashing the route lamps, and a number of supervisory lamps to indicate various operating stages and conditions. The jacks immediately above this panel, under the heavy white lines,

are for the state names. All the other jacks are for the route lamps.

On the pilaster at the extreme left are four fifteen-foot columns of red lamps. Each column times one step in handling a call. The lowest lamp in a column lights at the beginning of a step and successive lamps each second thereafter. The first column, "Placing the Call," times from the instant the handset is lifted until the toll operator has recorded the call. The second column, "Making the Connection," gives the time required by the operator to reach the operator at the called office, pass the number to her, and for ringing to start. The third times the ringing, and the fourth, obtaining the particular person after the telephone is answered. Only the first two measure telephone service, since the last two intervals depend on the called subscriber.

The time indicators are operated by a chain of ten counting relays under control of a timer giving sixty interruptions per minute and lighting one lamp a second. The tenth relay transfers the control of the ten lighted lamps to a holding relay, and releases the counting relays to count off the next ten seconds. Each indicator has a starting relay, which when operated seizes the counting circuit. Since the four intervals are immediately successive, the circuit is arranged so that operation of the second starting relay stops the first indicator and holds its lamps lighted. Similarly for the third and fourth indicators. The fourth is stopped by the map operator when the particular person called answers. The lights of all four are extinguished when the map operator transfers the outgoing toll circuit from one booth to the other booth.

## Eta Kappa Nu Award

*Larned A. Meacham, inventor of the bridge-stabilized oscillator circuit described in the picture section of this issue, has just been chosen to receive the* 1939 *Eta Kappa Nu Recognition of Outstanding Young Electrical Engineers. The award is made annually by this honorary electrical engineering society to electrical engineers who have been graduated not more than ten years and who are less than thirty-five years old, for "meritorious service in the interests of their fellow men." Mr. Meacham was cited for "his distinguished research in the generation of constant-frequency currents, and his exceptional participation in the cultural life of the community."*

# Recording Transient Disturbances

By O. D. GRISMORE
*Protection Development Department*

COMMUNICATION lines are subject to different kinds of transient electrical disturbances that may affect transmission or otherwise interfere with the use of the circuit. Such disturbances may arise, for example, from faults on adjacent power circuits or from lightning storms. It is important to know how often such disturbances occur, and their magnitude and duration, so that adequate precautions may be taken to minimize their effects. Since individual disturbances usually last only for a fraction of a second, and occur at unpredictable times, their study is facilitated by the use of some form of automatic oscillograph that will be set into action by the disturbance itself and will remain in operation only long enough to make sure that the entire disturbance has been recorded. Since these oscillographs will frequently be located at isolated places, they must be capable of making a number of such records without maintenance attention. For many purposes, it is also important to provide automatic means for recording the time of occurrence of the disturbance.

The first machine of this type was built a number of years ago for recording inductive disturbances from power systems. In more recent types of instruments designed primarily for this purpose, improvements have been made to embody changes that experience proved desirable or to incor-

porate new apparatus as it became available. In their major features, however, these later instruments are like the earlier ones. A relay is provided that operates and locks up whenever the voltage or current on the line changes by more than a predetermined amount. The oscillograph lamp is lighted, and the film movement is started by the operation of this relay, but all subsequent operations are controlled by a sequence switch. The galvanometer element is connected permanently across the line, and the record will begin on the moving film as soon as the lamp is lighted. The film is allowed to run for a time determined by the sequence switch, and is then stopped, and the lamp turned off. A separate optical system is then brought into action to photograph the face of a calendar clock on the film. After this, the film is again started and run long enough to store all the exposed section in a light-tight magazine.

Either 35- or 70-millimeter motion-picture film in 200-foot lengths is used, and film speeds from .04 to 60 inches per second are provided. The speed is preselected depending on the type of disturbance that is being studied, but for most work ten inches per second is used. The length of the record may be anything up to the 200-foot length of the film but is usually from three to ten seconds, corresponding roughly to from three to eight feet.

The photographic recording system consists of a light-tight compartment holding two magazines—one for the unexposed and one for the exposed film. The film passes from the first magazine, through a film guide where the recording takes place, then over a driving sprocket and into the other magazine. The driving sprocket is connected through a magnetic clutch to the driving motor, which runs continuously. To reduce the time required to accelerate the film, all the moving members of the clutch have been made as light as possible, and a spring drive has been provided between the clutch and the take-up so that only the sprocket and a short strip of film are accelerated when the clutch is

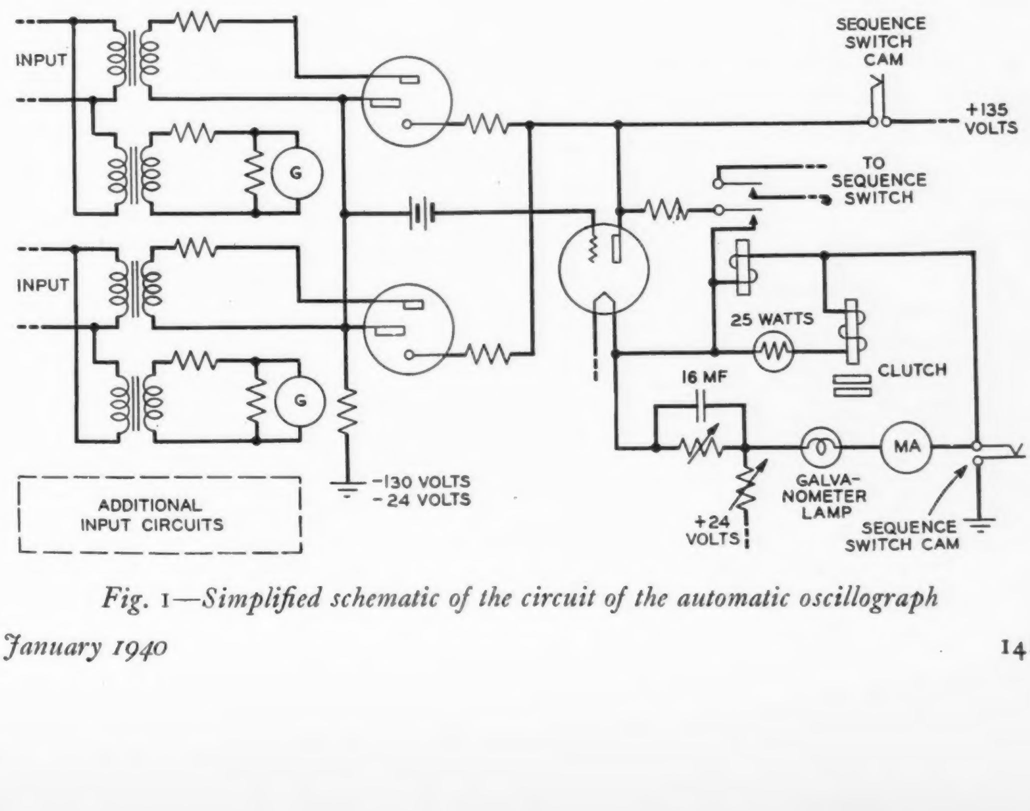



*Fig. 1—Simplified schematic of the circuit of the automatic oscillograph*

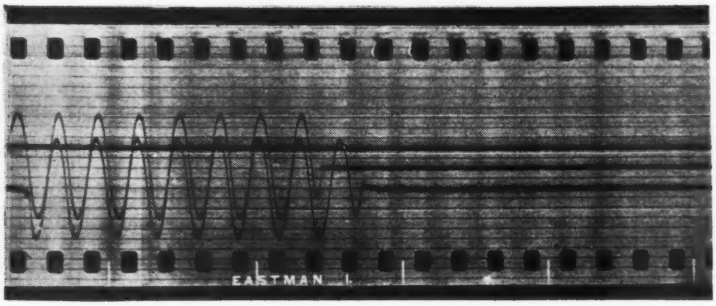



*Fig. 2—Typical oscillogram made with the delay network in the circuit of the automatic oscillograph*

first operated. After the first few turns of the sprocket, the spring is wound up, and the take-up is driven through it.

The first models of the machine used a reflecting type galvanometer. This instrument is rugged and simple and has a uniform response up to 800 cycles per second, but it is somewhat bulky and does not readily permit more than three or four simultaneous records to be made on the same strip of film.

The string galvanometer* is much more satisfactory in these respects, and it has been used in most of the more recent machines. It lends itself readily to multi-element construction, and as many as six elements have been built into a single field. The frequency characteristic of the string galvanometer is substantially better than that of the reflection type. With either resistance or resonant shunts for damping, its response is uniform up to 3000 cycles, and by use of suitable networks its uniform response can be extended to 10,000 cycles. Since its original application, the string galvanometer has been modified in order to secure greater stability of operation and smaller size and power consumption.

The original system used an exposed clock and a magnetically tripped shutter. As a result the pictures of the clock face varied in intensity due to the difference in illumination between day and night.

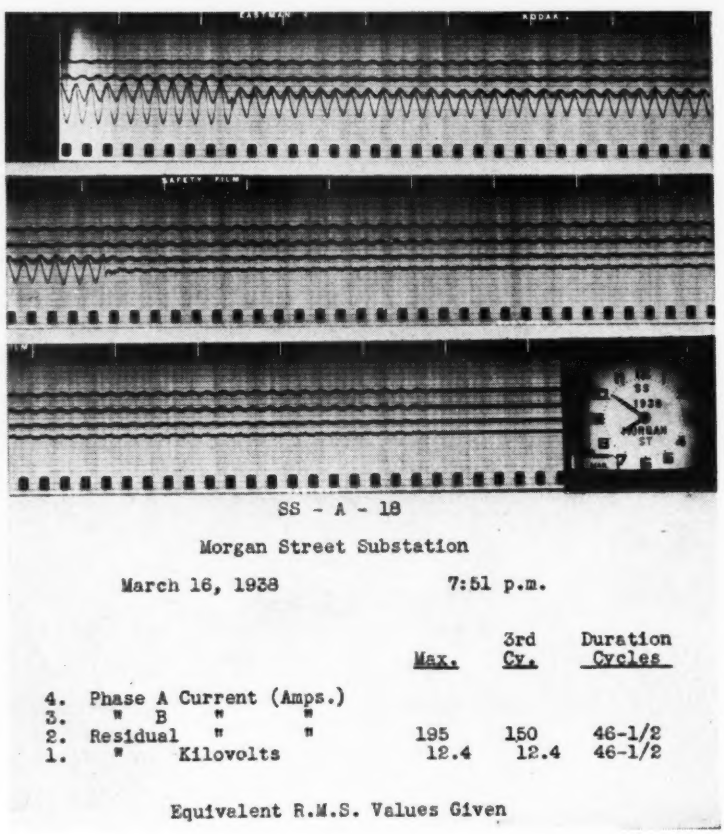



*Fig. 3—Method of mounting films for study*

*Record, *March,* 1927, *p.* 225; *Aug.,* 1930, *p.* 580; *June,* 1935, *p.* 145.

Moreover the mechanical shutter gave some trouble in the field. In the more recent machines, therefore, a twin-face clock has been used, with one face exposed, where it may be seen and its time checked at any time, and the other face in a light-tight compartment with a lamp and lens system. The lamp is lighted by the sequence switch at the right moment and is held lighted just long enough to give the proper exposure, so that no shutter is needed.

In an automatic oscillograph, quick starting is essential; and it is important, therefore, either to keep the lamp burning continuously, which would be uneconomical, or to reduce the period ordinarily required for the filament to heat up. This has been done, first by using a two-watt flashlight lamp, which requires little heat to raise its temperature to the operating value because of the small size of the filament; second, by keeping the filament at a dull red heat all the time; and third, by using the charging current of a condenser to bring the filament of the lamp up to its operating temperature.

In the early instruments, high-speed polar relays were used to start the oscillograph, and two were required in each input circuit so as to operate regardless of the direction of the initial pulse of current. In the later machines, however, these relays have been replaced by cold-cathode tubes, which are faster, and since they operate on pulses in either direction, one tube replaces two relays. A discharge through any one of the cold cathode tubes will trip a hot-cathode gas tube that starts the oscillograph.

A simplified schematic of the circuit employed is shown in Figure 1. When any one of the cold-cathode tubes operates, the gas tube is tripped, and current from the 135-volt supply passes through the tube, and the relay winding to ground. Current also flows through two branch circuits, one including the clutch, and one the galvanometer lamp. This latter circuit

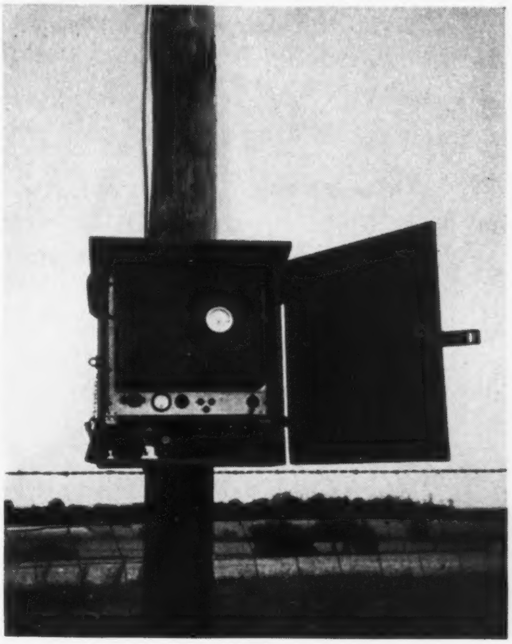


*Fig. 4—Field installation of the small automatic recording oscillograph*

has a feed also from a 24-volt source through a resistance, which supplies current for keeping the lamp at a dull heat during idle periods. The lamp is brought to full brightness by the initial pulse of current through the condenser, which will have more than 100 volts impressed across it. As the circuit approaches the steady-state condition, the condenser ceases to pass current and the resistance maintains the desired voltage across the lamp. When the relay operates, it locks itself in and also closes a contact that starts the sequence switch, which then controls the operation. Only its contacts in the 135-volt and ground leads are indicated on the diagram.

With this circuit, initiation of the record is possible within .01 second after the transient reaches the operating magnitude, and for many studies a delay of .01 second is not objectionable. Since there are cases where the initial portion of the disturbance is important, however, some means were required for recording it. A delay network was therefore designed that provided a delay of .016 second in the range from 25 to 513 cycles. This network, of course, is connected only in the galvanometer circuit—the gas tubes operating on the input circuit without delay. By this means a short section of film is exposed before the disturbance reaches the oscillograph strings, so that the entire disturbance is recorded. An oscillogram taken in this way is given as Figure 2. It shows the record of a sixty-cycle current on two strings—one connected directly to the circuit and one through the delay network. In the latter, a short section of zero disturbance is shown before the disturbance begins. The similarity of the two curves except for their time displacements indicates the very small amount of distortion that has been introduced by the delay circuit.

Another arrangement, which avoids the loss of most of the initial portions of a transient disturbance, has been used in the course of development work. A cathode-ray oscillograph has been constructed in which the starting time is less than ten micro-seconds. This permits the photographing on a film of the disturbance as registered on the cathode-ray screen.

The automatic recording oscillograph has been in use since 1926 in a variety of studies in many locations. Although originally designed for recording disturbances on communication circuits, its use has been extended to power and electric railway lines to study disturbances that may affect adjacent communication circuits. Wherever installed, these types to date have been inspected and calibrated at intervals of from three to six months by a member of the Laboratories staff. In addition there is a routine maintenance, which includes a daily entry in a log, replacement of lamps and film, and forwarding of the log and film to New York for analysis. After the film has been developed, prints are made, and mounted for analysis as shown in Figure 3.

As already noted, these machines were modified from time to time as conditions warranted. More recently a smaller and less expensive form of the oscillograph has been developed for mounting on poles and similar places where space is at a premium. Sixteen-millimeter film and a permanent magnet galvanometer with two elements are employed. Only a single film speed of six inches per minute is provided, but this speed may be changed by a simple gear replacement. This machine occupies a panel space of only fifteen inches, and is installed in a totally enclosing cabinet. A field installation is shown in Figure 4.

# News of the Month

### Australian Type-J System in Service

Commercial service over the type-J carrier-telephone system between Sydney and Melbourne, Australia, was begun on November 2, 1939. This system, sold to the Australian Post Office Department by the International Standard Electric Corporation, was manufactured by the Western Electric Company. It is understood that the Postmaster-General's Department is well pleased with the performance of the system and that the circuits which it affords have resulted in a considerable speeding-up of traffic between Sydney and Melbourne. J. T. O'Leary of the Laboratories, who went to Australia to assist in the installation and lining-up of this system, is returning to New York.

### Colloquium

At the November 20 meeting of the Colloquium, Professor P. W. Bridgman of Harvard University described the *Effect of High Pressure on Metals*. The principles of a new technique were discussed by which it is possible to measure volume changes produced in small quantities of various materials up to 50,000 kg/cm$^2$, and to measure electrically a variety of other effects in larger quantities of material up to 30,000 kg/cm$^2$. The methods by which reference points are established in the region of high pressure were pointed out. Various effects of high pressure on metals have been measured and described. These include volume compression, polymorphic transition, and change of electrical resistance.

C. S. Fuller spoke on *Some Properties of Synthetic Substances Composed of Long-Chain Organic Molecules* at the meeting held on December 4. Only during the last decade has the importance of long-chain molecules in determining the properties of the structural substances of plants and animals become generally recognized. Today considerable attention is being devoted to the synthesis of chain molecules having diverse chemical structures. Relatively little progress has been made, however, in explaining the unique physical behavior of these substances. Mr. Fuller considered the nature of the processes by means of which long-chains are synthesized with particular em-

*Photograph by Bachrach*

*Clarence G. Stoll, elected president of the Western Electric Company to succeed Edgar S. Bloom who retired on December 31 at the standard retirement age in the Bell System. Since 1928 Mr. Stoll has been vice-president in charge of operations and, since 1927, a director of Bell Telephone Laboratories*

*At a luncheon on December 8, to celebrate the tenth anniversary of commercial telephone service between ships and shore, R. A. Heising presented to Commodore H. A. Cunningham the handset installed in his cabin on the "Leviathan," of which he was then in command*

phasis on the origin of the properties of long-chain substances. The physical properties of typical synthetic polymers representing the crystalline, glassy and rubbery states of matter were described in relation to the nature of the molecules composing them.

### First Aid Conference

On November 16 a First Aid Conference was held in the West Street Auditorium for those members of the Laboratories who have been specially trained to administer First Aid treatments in cases of accident or emergency sickness arising at locations of the Laboratories other than West Street; or to instruct groups of their associates in First Aid classes at their respective locations. All members of the Conference are graduates of the joint First Aid course of the Laboratories and the American Red Cross. Since 1930 these individuals and other trained personnel have rendered all First Aid treatments required by members of the Laboratories at these locations.

The Conference was devoted to the discussion, demonstration and practice of standard First Aid procedures in connection with the treatment of common emergencies and was the first of annual one-day conferences which will be arranged to enable this group to review their methods of treatment, discuss problems which may have arisen in the course of their experience and become acquainted with revised First Aid procedures that are recommended by the Red Cross.

G. B. Thomas addressed the group at luncheon, expressing the appreciation of the Laboratories for the services which they had rendered as First Aiders. Arrangements for the day's program were made by L. E. Coon of the Employee Service Department. J. S. Edwards directed the review work, assisted by E. Alisch, J. M. Dunham, L. S. Inskip, J. Leutritz, L. R. Lowry,

### Members of the Laboratories Attending First Aid Conference at West Street

*Deal*
J. P. Schafer

*Holmdel*
L. J. Barker
L. R. Lowry

*Summit*
J. Leutritz

*Whippany*
A. F. Dolan

*Davis Building*
E. Alisch
T. M. Benseler
D. W. Bodle

*Davis Building*
Elizabeth M. Culbert
J. M. Dunham
R. Haard
L. S. Inskip
E. Reinberg
Margaret Remmelman
G. J. Wismar

*Graybar-Varick Building*
C. F. Benner
N. C. Brower
C. A. Dahlbom
O. E. DeLange

*Graybar-Varick Building*
P. J. Doorly
J. R. Erickson
H. F. Gartner
O. D. Grismore
R. C. Hersh
J. W. Hoek
E. J. McCarthy
J. J. McMahon
A. E. Melhose
R. M. Pease
G. A. Smith
W. F. Smith
J. E. Tarr

*Graybar-Varick Building*
Elena R. Tighe
H. R. Vail
M. L. Weber
H. F. Winter

*West Street*
L. E. Coon
J. S. Edwards
Martha Markthaler
C. Erwin Nelson
W. C. Somers
L. E. Wescoat

Martha Markthaler, C. Erwin Nelson, J. P. Schafer, W. C. Somers, and L. C. Wescoat, First Aid Instructors.

## News Notes

F. B. Jewett, as a member of the Board of Visitors of the National Bureau of Standards, attended the annual meeting of the committee during which finances were reviewed and equipment inspected.

On the following day, Dr. Jewett spoke before the Engineers Club of Philadelphia regarding some of the newer aspects of developments in progress at the Laboratories. J. R. Townsend, who accompanied him, discussed some motion studies now in progress with the aid of high-speed motion pictures.

R. W. King, on November 20, spoke on *The Future Significance of Our Present Industrial Age* at an afternoon meeting of the College Club of the Oranges.

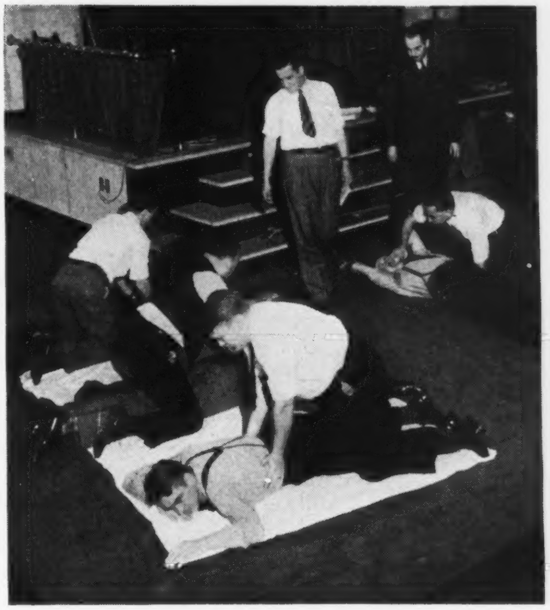
Dr. O. E. Buckley, formerly Vice-Chairman of the Engineering Foundation Board, has succeeded to the Chairmanship of that organization, following the death of Professor Beggs of Princeton University.

Dr. Buckley has recently been appointed a member of the Charles LeGeyt Fortescue Fellowship Committee of the A.I.E.E. for a three-year term ending July 31, 1942. This Committee will administer a graduate fellowship fund, the gift of the Westinghouse Electric and Manufacturing Company in memory of Mr. Fortescue.

A. F. Dixon has been appointed chairman of the Winter Convention Committee of the A.I.E.E. which will be responsible for handling the Mid-winter Convention of the Institute. G. F. Fowler is a member of the Inspection Trips Committee.

H. S. Sheppard gave a lecture on *What the Bell Laboratories Does for the New York Telephone Company* in connection with the New York Telephone Company's Out-of-Hour Courses.

*Application of fixed-traction splints for fractures of the leg and arm*



*Practicing artificial respiration during First Aid review conference*

T. H. Crabtree and A. H. Miller visited the Baltimore & Ohio Railroad at Dayton, Ohio, on matters pertaining to the installation of loudspeaker sets to supplement the telephone equipment that is used on the railroad's train-dispatching system.

C. V. Obst of the Apparatus Development Department received a B.M.E. degree from Brooklyn Polytechnic Institute last June.

E. C. F. Matthews was in Hawthorne the week of November 27 to discuss keys used in combined telephone sets.

J. H. Bower visited the dry battery manufacturing plants of the National Carbon Company at Cleveland and Fremont, Ohio, and also made a visit to the Nela Park Engineering Department of the General Electric Company to discuss flashlight lamp problems.

Recently N. Insley, J. C. Wright, and E. B. Wheeler visited the Champion Lamp Works of the Consolidated Electric Company at Lynn, Massachusetts; also the Lamp Division of the Hygrade Sylvania Corporation at Salem, Massachusetts, to discuss lamp specifications.

An Observational Standard is a physical object which has been selected and approved as establishing characteristics of engineering importance; for example, a sample of metal finish. Such standards, as well as drafting standards, were discussed by T. C. M. Woodbury on a recent visit to Hawthorne. Mr. Woodbury also visited H. W. Bearce of the National Bureau of

Standards at Washington to discuss tolerances and allowances.

J. C. Wright and E. B. Wheeler attended a quality survey on switchboard lamps at Hawthorne and also discussed other lamp problems with the Manufacturing Department. Later they visited the Nela Park Laboratories of the General Electric Company, Cleveland, to discuss specifications on illuminating lamps.

On November 29, W. Fondiller, W. L. Casper, W. J. Shackelton, F. J. Given, H. Whittle, R. H. Mills, W. E. Burke and F. J. Hallenbeck met with Western Electric engineers in J. L. Alden's office at Kearny to discuss network standardization problems.

W. D. Voelker recently visited the Leeds and Northrup Company at Philadelphia to inspect a high-precision capacitance bridge now under construction for the Laboratories.

Stanley J. Harazim visited the Special Products Shop at Kearny to discuss problems involved in the manufacture of apparatus to be used for the identification of wires during cable transfer operations.

A. H. Volz, also at Kearny, discussed manufacturing problems on a proposed new test set for use in testing electrolytic condensers in the telephone plant.

A. L. Richey visited Cleveland, Detroit, Chicago, Milwaukee, Minneapolis, Omaha and Denver on problems concerned with the introduction of NA cable terminals. S. R. King with H. W. Butler of the O. and E. Department visited New Haven, Boston, and Albany on the same type of work.

R. J. Nossaman visited Pittsburgh, Cincinnati, Columbus, Indianapolis, St. Louis, and Chicago and E. J. Bonnesen visited Philadelphia, Washington, Richmond and Atlanta in connection with outside plant field requirements.

Field trials of lead-covered cable with rubber covering over the sheath took R. P. Ashbaugh to Forked River, New Jersey, to examine the results of lightning damage to experimental buried cable of this type, and to Rikers Island in the Bronx to see some cable with this type of sheath being installed there.

J. M. Hardesty, with S. A. Haviland of the American Telephone and Telegraph Company and R. M. Randolph of the New Jersey Bell Telephone Company, visited Atlantic City to investigate the construction of concrete manholes. Later, in company with A. C. Roehm of the New York Telephone Company and S. M. Sutton of the Laboratories, Mr. Hardesty visited Long Island to study the underground plant construction associated with elimination of grade crossings on the Long Island Railroad.

R. H. Colley attended the meeting of the Executive Committee of the American Wood-Preservers' Association held October 6 and 7 in Cincinnati. He also visited suppliers, Associated Companies, and joint-use electrical companies in Minneapolis, Madison, and Chicago in connection with the use of shaved and full-length creosoted western red-cedar poles.

Dr. Colley also continued his observations of experimental and commercial production of creosoted southern pine poles, with particular emphasis on methods of controlling deterioration

C. S. Demarest
*of the Switching Research Department completed thirty years of Bell System service on December* 10

S. H. Everett
*of the Central Office Switching Development Department completed thirty years of Bell System service on November* 1

W. H. Bendernagel
*of the Equipment Development Department completed thirty years of Bell System service on November* 18

*First annual conference of the Laboratories' personnel trained to administer First Aid treatments. In this photograph E. Alisch is discussing artificial respiration*

during seasoning, at Texarkana, Gulfport, Atlanta and Spartanburg.

W. Y. Lang was at the Teletype Corporation in Chicago in connection with an engineering survey on teletypewriter apparatus.

J. D. Hubbell visited the Western Electric Company at Hawthorne on manufacturing problems of ringers.

C. Erland Nelson was in Pittsburgh and Buffalo in connection with contact studies.

F. E. Henderson of the Hawthorne Works of the Western Electric Company visited the Laboratories to discuss relay development problems.

E. Lakatos received an LL.B. degree cum laude from the New York Law School and passed the bar examination.

L. N. Hampton visited the Houdaille-Hershey Corporation at Lowell, Massachusetts, for the purpose of discussing problems that have arisen in the manufacture of telephone booth fans and ventilators.

C. G. McCormick visited the Hawthorne plant of the Western Electric Company to discuss manufacturing problems on step-by-step banks.

J. J. Kuhn visited several community dial exchanges in Jacksonville and the new step-by-step central office installation in Augusta.

The Nassau Smelting and Refining Company at Tottenville, Staten Island, was recently visited by R. R. Williams, R. M. Burns, E. E. Schumacher and H. E. Haring.

H. Fletcher attended a meeting of the Ohio State University Research Foundation at Columbus, Ohio.

F. C. Nix gave a talk on *Order and Disorder in Alloys* at the U. S. Steel Corporation research laboratory at Kearny.

C. C. Hipkins was in Hawthorne to discuss various finishing problems.

H. G. Arlt addressed the Engineering Conference Group at the Western Electric Company, Kearny, on the subject of *Organic Finishes*.

Mr. Arlt has been appointed a member of Committee D9, on electrical insulating materials, of the American Society for Testing Materials.

B. L. Clarke has been appointed a member of the Committee on Student Medals of the American Institute of Chemists.

G. T. Kohman attended a meeting of the Utilities Coördinated Research Committee at Massachusetts Institute of Technology to discuss insulating oils.

J. H. Ingmanson went to the Point Breeze plant of the Western Electric Company in connection with rubber-covered wire problems. He also visited the du Pont Company.

A. M. Skellet presented a paper on *The Coronaviser, an Instrument for Observing the Solar Corona without an Eclipse* at the National Academy of Science meeting in Providence and at the American Philosophical Society meeting at Philadelphia.

K. K. Darrow presented a paper at the American Philosophical Society in Philadelphia on *Status of Nuclear Theory*.

L. Egerton and D. A. McLean visited the Dexter and Stevens Paper Mills and the General Electric Laboratories, Pittsfield, Massachusetts, where they discussed paper problems.

At Boston, G. T. Kohman, D. A. McLean, L. Egerton, E. J. Murphy, S. O. Morgan and W. A. Yager attended the Conference on Electrical Insulation of the National Research Council. Papers were presented by Mr. Egerton on *The Use of Statistical Methods in Insulation Research* and by Mr. Murphy on *The Dependence of the Conductivity of Dry Paper on Temperature and Voltage*. Mr. McLean was co-author of both papers.

C. H. Prescott participated in a symposium of *Temperature and Its Measurement* under the auspices of the American Institute of Physics. He contributed a paper on *The Pyrometry of Oxide Coated Filaments*.

K. K. Darrow spoke at Mt. Holyoke College on *Nuclear Fission* and at Vassar College on *Cosmic Rays*. He also attended the American Physical Society meeting at Chicago.

W. C. Jones delivered a talk on *Electroacoustical Measurements* on November 13 as one of seven lectures on *Modern Methods for Communication Measurements* sponsored by the Communication Group of the New York section A.I.E.E.

F. S. Goucher, assisted by J. R. Haynes, gave his demonstration lecture on *The Microphone and Research* at a joint meeting of the Communication Group of A.I.E.E. on November 29 in Philadelphia. They also gave this lecture before a combined meeting of the American Physical Society and the Chicago Physics Club in the Museum of Science and Industry at Chicago on December 1.

V. E. Legg spoke on magnetic materials before the Engineering Conference Group of the Western Electric Company at Kearny.

W. M. Goodall's paper, *The Solar Cycle and the $F_2$ Region of the Ionosphere*, presented before the Pacific Coast convention of the I.R.E. last June and the Fourteenth Annual Convention last September, was published in the November *Proceedings* of the Institute.

J. O. McNally spoke on *Secondary Emission* at the December 1 meeting of the Radio Colloquium held at the Deal Radio Laboratory.

J. C. Steinberg and H. C. Montgomery took part in Dr. Watson Davis' series of programs, *Adventures in Science*, over the Columbia Broadcasting System on November 27. The program was devoted to a description of the hearing test exhibits at the New York and San Francisco World's Fairs together with a demonstration showing the effect of deafness on the ability to understand speech.

The joint fall meeting of the Institute of Radio Engineers and the Radio Manufacturers Association, held in Rochester, was attended by G. Rodwin, F. W. Reynolds and R. A. Heising. Mr. Heising also attended a meeting of the Baltimore section of the I.R.E.

J. G. Ferguson visited Hawthorne to discuss problems involving community dial exchanges.

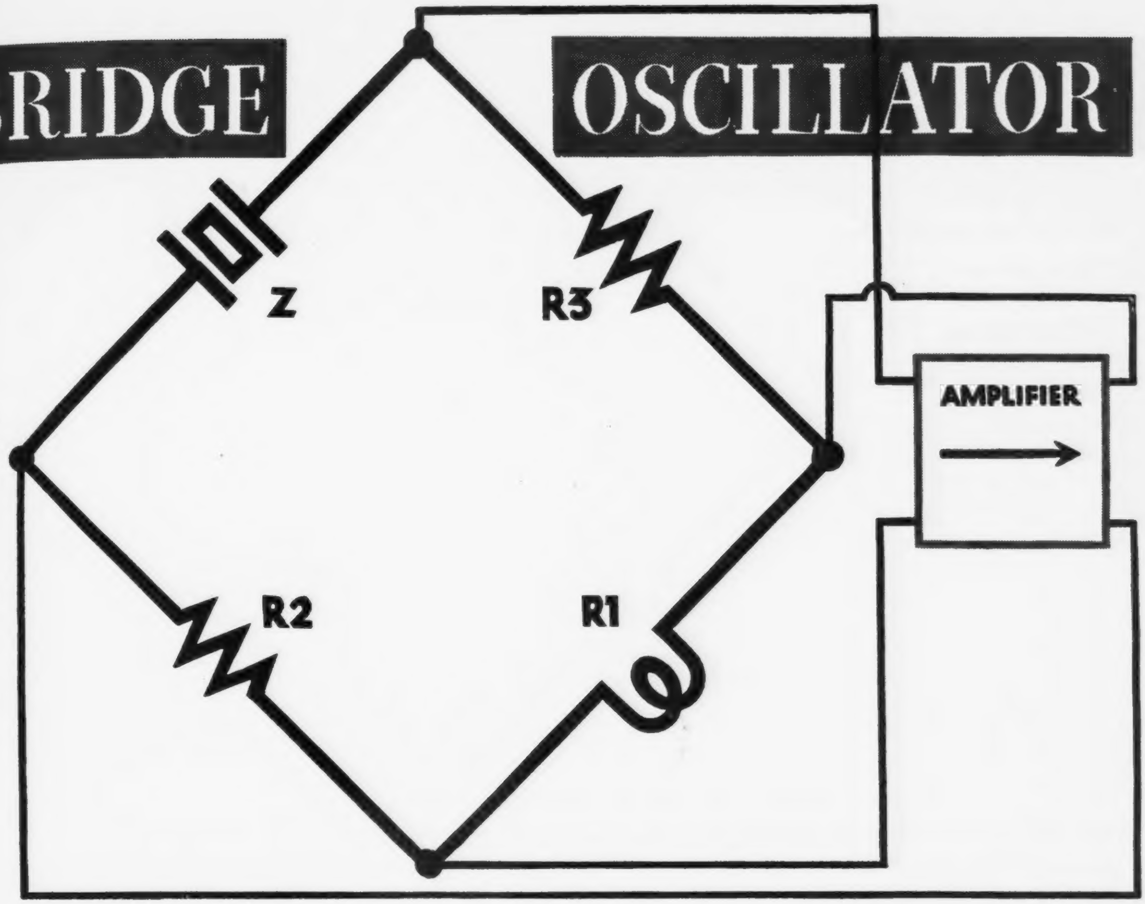
W. G. Schaer and A. C. Gilmore visited the new Weather Bureau Subcenter at Newark.

At Philadelphia, G. A. Hurst, H. W. Heimbach, G. F. Sohnle and L. A. Dorff discussed with engineers of The Bell Telephone Company of Pennsylvania plans for a trial of AC key pulsing from a toll to a dial-panel office.

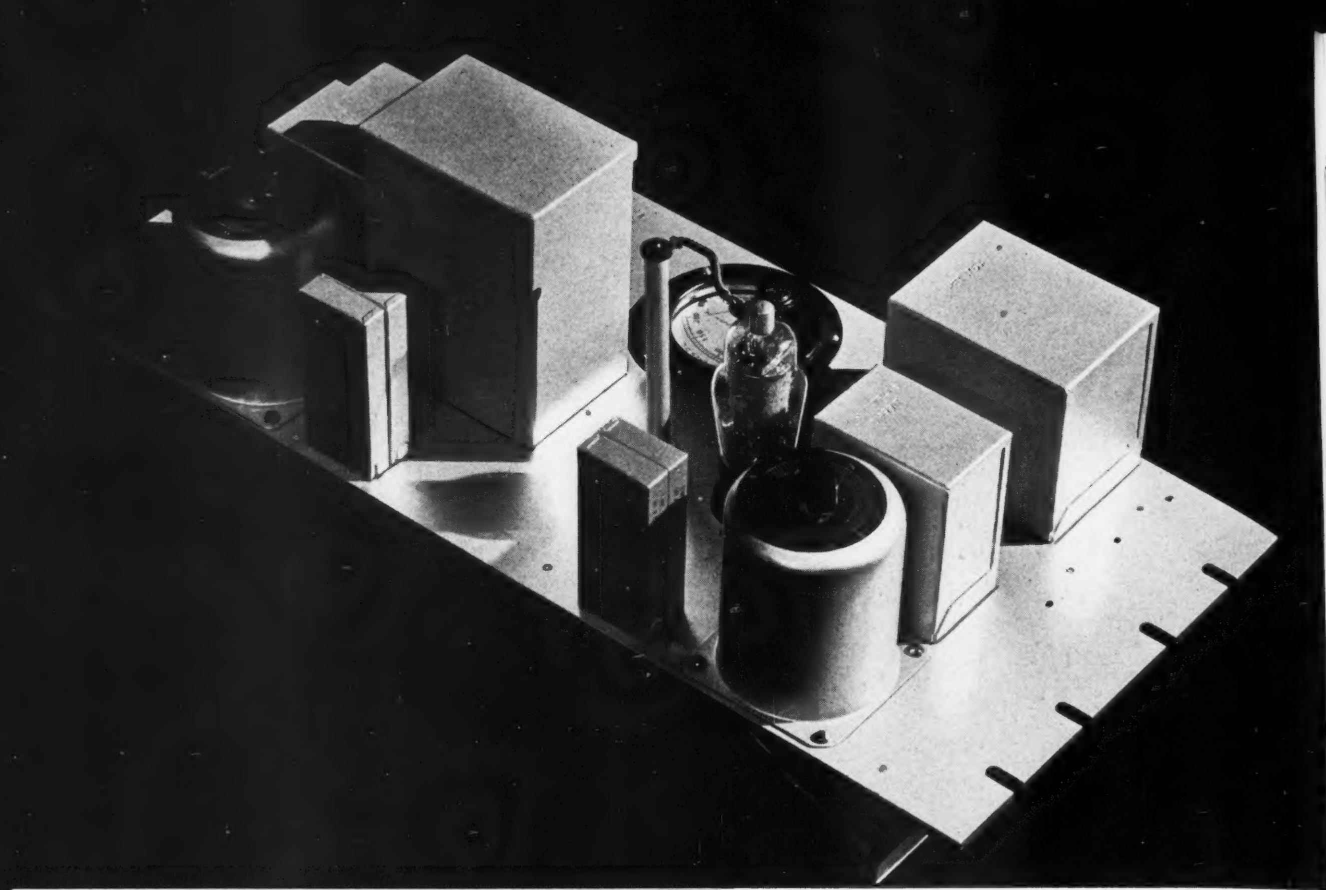
## Members of the Laboratories to Whom Patents Were Issued During the Months of September, October and November

| | | | |
|---|---|---|---|
| M. W. Baldwin, Jr. | H. W. Dudley | R. F. Mallina | V. L. Ronci |
| W. C. Beach | K. E. Fitch | F. S. Malm | C. F. P. Rose |
| B. G. Bjornson (2) | J. R. Fry | W. P. Mason (3) | C. W. Schramm |
| K. C. Black | F. J. Given | D. T. May | A. H. Shangle (2) |
| R. R. Blair (3) | M. S. Glass | P. Mertz | R. A. Shetzline |
| F. E. Blount | L. N. Hampton | D. D. Miller | F. J. Singer |
| A. E. Bowen | F. A. Hoyt | R. L. Miller (2) | B. Slade |
| L. J. Bowne | H. E. Ives (3) | O. R. Miller | G. R. Stibitz |
| H. A. Bredehoft | W. Kalin | P. E. Mills | P. W. Swenson |
| D. R. Brobst | A. C. Keller | F. C. Nix | R. A. Sykes |
| W. W. Carpenter | A. R. Kemp | F. R. Norton (2) | C. C. Taylor |
| R. S. Caruthers | F. S. Kinkead (2) | R. L. Peek, Jr. | G. K. Teal |
| J. E. Clark | E. Lakatos | G. E. Perreault | A. L. Thuras |
| W. W. Cramer | F. A. Leibe (2) | E. Peterson | J. F. Toomey |
| A. M. Curtis | H. A. Lewis | G. H. Peterson | H. N. Wagar |
| R. C. Dehmel | C. W. Lowe | N. J. Pierce | J. F. Wentz |
| S. Doba, Jr. | G. R. Lum | F. A. Polkinghorn | S. B. Wright |

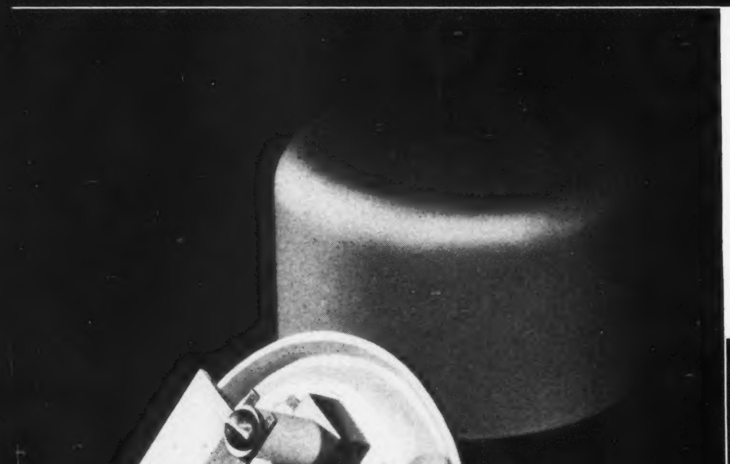
# BRIDGE OSCILLATOR

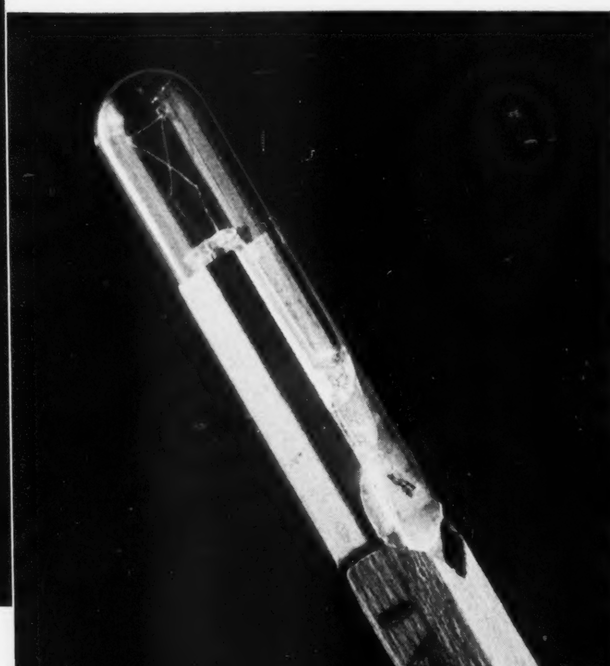



An ideal oscillator would maintain a fixed amplitude and frequency regardless of changes in operating conditions. This ideal is approached by the "Bridge Oscillator" whose circuit is shown above. A stable, high-Q crystal (Z) forming one leg of a Wheatstone bridge is driven by a class A amplifier. Two arms of the bridge are fixed resistances (R2, R3); the fourth (R1) is a lamp whose thermally controlled resistance is designed to keep the bridge out of balance just enough to sustain oscillation. As the temperature of the lamp filament depends upon the amplitude of oscillation, any small change in this amplitude or in the gain of the amplifier is immediately corrected by a slight readjustment of the bridge balance. The frequency is stabilized at the particular value for which the crystal impedance is a pure resistance. This is the only frequency at which the impedance arm of the Wheatstone bridge can approach balance with the three resistive arms.

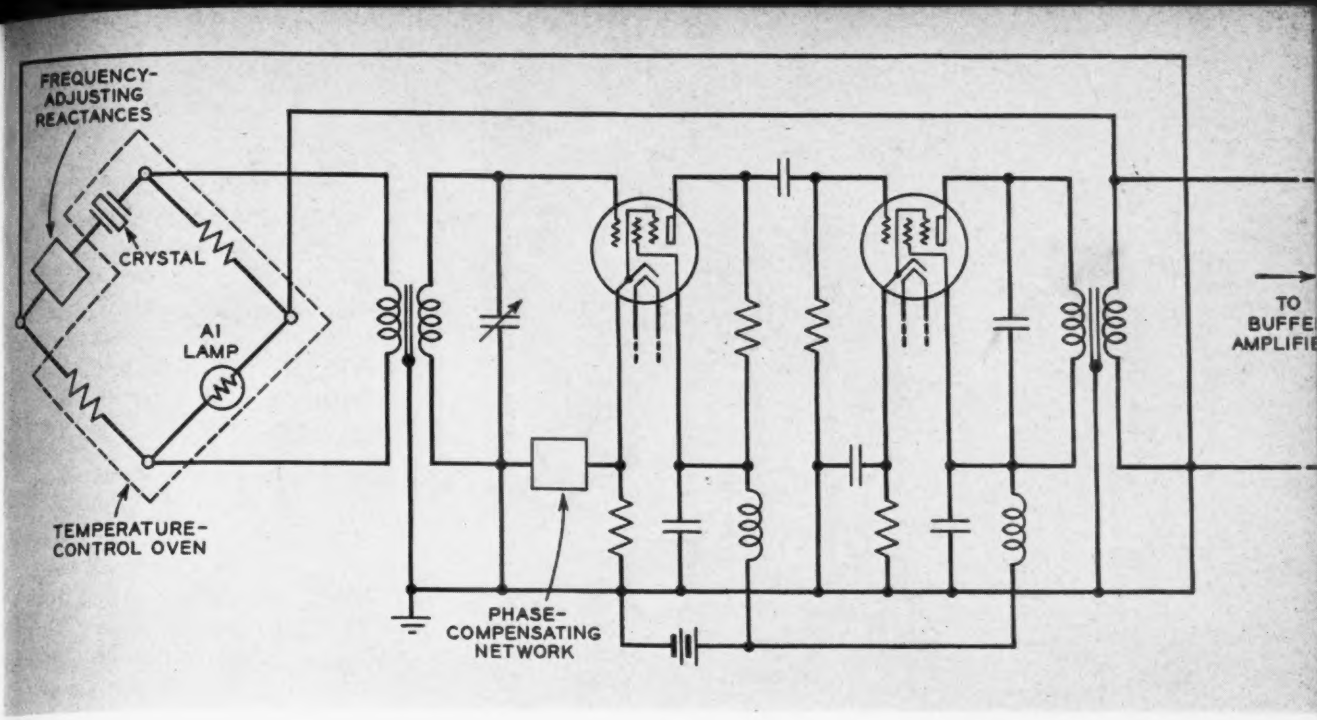


The bridge-stabilized type of oscillator was developed in the Laboratories for applications requiring extreme frequency stability. The experimental model shown above is used for testing 100-kc quartz resonators. It is arranged to be controlled in frequency by any suitable crystal, which is connected to terminals on the oscillator panel.



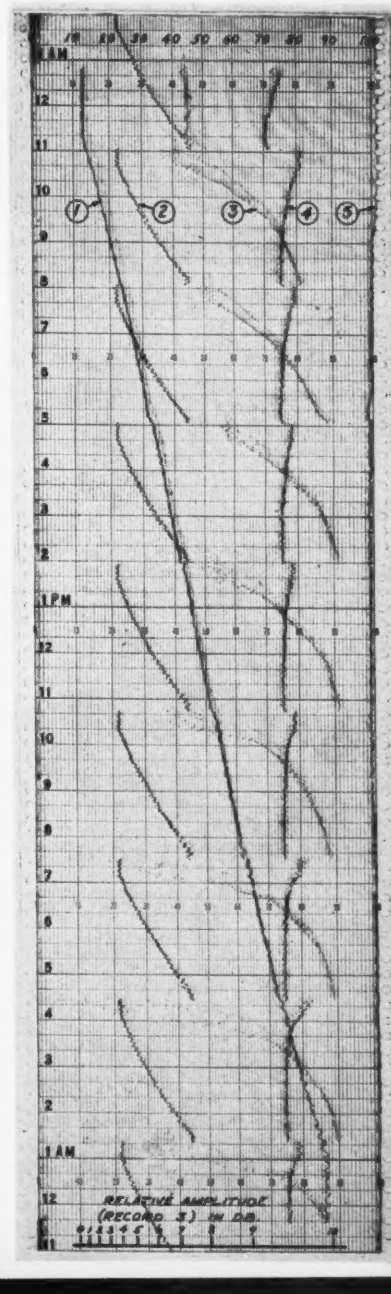


\ low temperature-coefficient crystal (above) adjusted or use in a 100-kc bridge oscillator, ready for sealng in its vacuum container. The crystal and the amiliar switchboard lamp (right) form two arms of he stabilizing bridge.

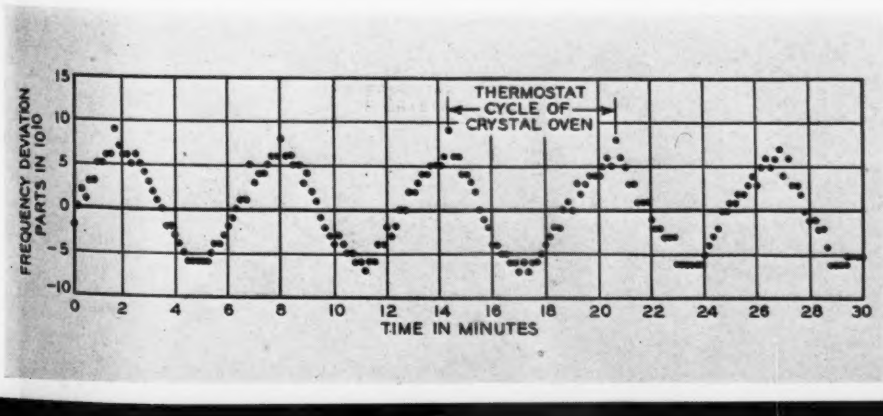


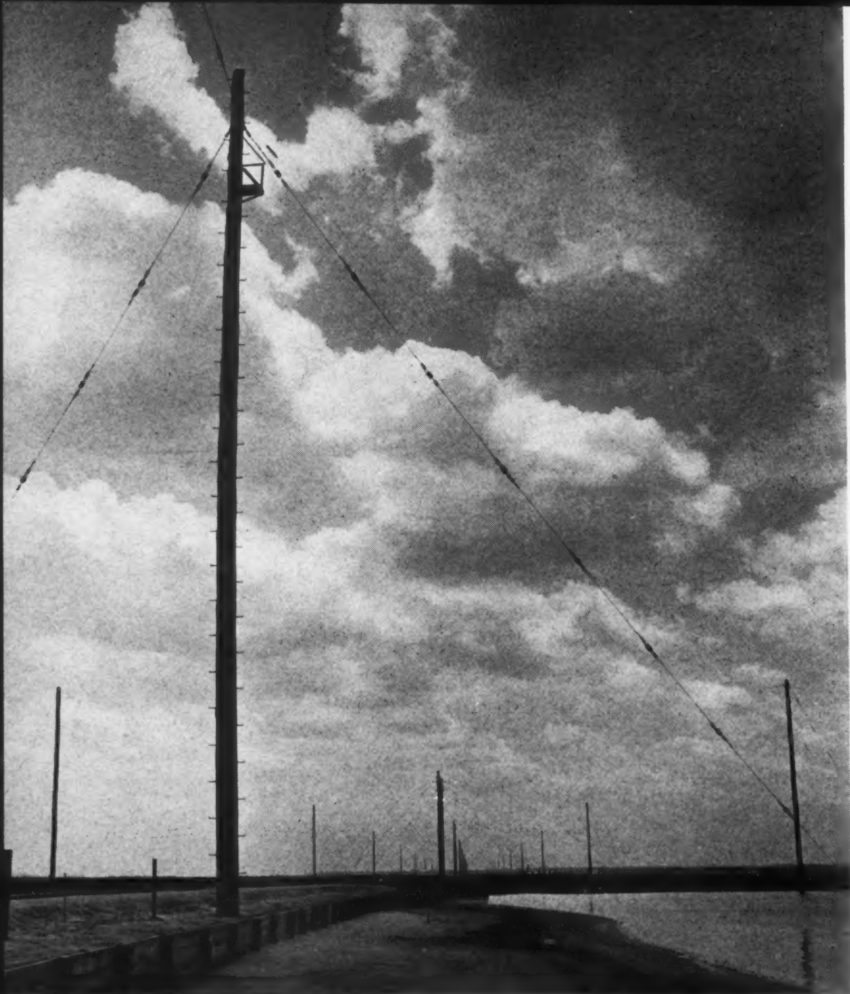

Simplified circuit schematic (above) of the bridge oscillator designed for the Bell System Frequency Standard by L. A. Meacham, who developed this type of oscillator. A two-stage amplifier provides high gain and correspondingly high stability. Variable reactances in series with the crystal afford manual adjustments of frequency over a narrow range. The phase-compensating network indicated in the cathode path of the first tube assists in overcoming any tendency of the circuit to break into undesired oscillation on account of its high gain.

At the right is a record of a laboratory test of the circuit above. (1) "B" supply voltage, varied from 174 to 25 volts by a motor-driven potentiometer. (2) "A" supply voltage, varied repeatedly from 22 to 11 volts (normal is 20 volts). (3) Oscillator output level; calibration is indicated at the bottom of the chart. (4) Oscillator frequency deviation; one division represents one part in $10^8$. (5) Check of full-scale calibration of frequency-measuring apparatus.




In studying the short-time variations of these stable generators under their normal operating conditions, special measuring equipment of extremely high sensitivity has been used. By precise timing of consecutive beats between a pair of the oscillators, their stabilities from minute to minute have been determined within one part in $10^{10}$. Typical results (below) show swings of $\pm 6$ parts in $10^{10}$, introduced by the thermostatic controls of the crystal ovens.





Bridge oscillators are used in the new single-sideband Musa system (left) as references to which certain intermediate carrier frequencies are automatically adjusted in order that their sidebands may be properly located with respect to the pass bands of crystal filters.

Recording instruments (below) of the Bell System Frequency Standard, operated by the Laboratories. Four bridge oscillators are the prime generators of this standard; any one of them can be chosen to supply the standard frequency, while the others are operated for standby and intercomparison purposes. L. A. Meacham and W. A. Marrison are examining a record chart.

A crystal chronometer, consisting of a bridge oscillator, frequency-dividing circuits, and a timing motor, has been loaned by the Laboratories to the American Geophysical Union and used aboard the submarine *Barracuda* (below) in making undersea gravity measurements in the West Indies. Difficult operating conditions were met successfully.

*Acme*

An installation of fluorescent lighting applied to a crossbar central office at Alexandria, Virginia, was inspected by W. G. Freeman, P. W. Sheatsley, E. K. Eberhart and W. W. Rindlaub, together with A. T. & T. and Western Electric engineers.

I. W. Brown made a trip to Des Moines in company with engineers from Hawthorne to discuss with the Telephone Company's engineers problems in connection with a new toll and step-by-step office for Council Bluffs, Iowa.

A. S. May was in Boston, Fitchburg and Greenfield, in connection with a telephone repeater trial installation.

J. H. Sole visited the Electric Products Company and the Ohio Bell Telephone Company in Cleveland, as well as the General Electric Company in Schenectady.

The current investigation of reserve engines took F. F. Siebert to Auburn, New York, and V. T. Callahan to Canton, Ohio, and Lansing, Michigan.

N. A. Froberg and E. B. Mechling studied noise conditions from power circuits at Burton, Magnolia and Chesterton, Ohio. Mr. Mechling then joined a group testing the new program-switching system at Omaha.

At Omaha, P. B. Murphy, J. T. Schott, E. B. Mechlin spent ten days inspecting and testing the new installation of the program amplifier, switching and reversing circuits.

T. L. Dimond spent several days in Salem, Ohio, inspecting an installation of step-by-step central office equipment of the 355 type.

E. W. Hancock on a recent visit to Lynn, Massachusetts, observed the Lynn crossbar installation.

W. H. Scheer visited Jonesville, New York, to observe the operation of the 380 type of crossbar community dial office.

During November, S. B. Williams spent three weeks in Seattle testifying at a hearing of the Pacific Telephone and Telegraph Company before the Department of Public Welfare of the State of Washington. Mr. Williams' testimony concerned the operation of two-party message registers as used in the panel system. Early in September he also spent another week in Seattle with H. S. Sheppard on the same case.

O. D. Engstrom and E. W. Houghton were at Houlton, Maine, to test additional long-wave receiver equipment recently installed there for use in studying improvements in long-wave operation.

J. J. Gilbert and W. M. Bishop visited the Okonite Company in Passaic to confer with their engineers on various problems concerned with the manufacture of submarine cable.

P. Mertz and C. L. Weis attended the I.R.E. meeting in Rochester at which certain television matters of interest were discussed.

B. Dysart and C. C. Fleming spent most of the month in the field in connection with the 3-megacycle repeater installation on the coaxial cable between New York and Philadelphia. K. C. Black, H. H. Benning, B. J. Kinsburg, B. H. Nordstrom, J. D. Sarros and J. J. Strodt also spent a number of days testing this installation.

During the months of November and December the following members of the Laboratories completed twenty years of service in the Bell System:

*Apparatus Development Department*

James Abbott, Jr. — D. C. Smith
J. R. Bardsley — A. D. Soper
S. T. Curran — C. C. Towne
Markley J. Wean

*Research Department*

W. S. Gorton — A. J. Parsons
Michael Tompa

*Systems Development Department*

W. T. Breckenridge — R. F. Massonneau
E. N. Danes — L. F. Porter
Carl Deelwater — C. W. Van Duyne
A. O. Easton — C. A. Wingardner
H. H. Harvey — T. J. Young

*Protection Development Department*

C. F. Boeck — R. K. Honaman

*Bureau of Publication*

B. A. Clarke

*General Service Department*

Miss Helen Cruger — Joseph Popino
D. R. McCormack — J. C. Roe
Miss Anna M. Ryan

*Plant Department*

T. E. Cassidy — E. W. Newman
L. E. Stolzenberg

*Patent Department*

J. H. Cozzens — W. J. Crumpton
W. L. Dawson

During November and December, A. B. Bailey, W. G. Domidion, H. C. Foreman, J. J. McMahon and F. H. Willis have been making ultra-high frequency surveys in the metropolitan New York area.

A test of long-distance telephone calls over wire circuits containing an emergency radio link between Holmdel and Ft. Monmouth was made for the officers of the United States Army on November 9. The equipment for the emergency radio link was designed and developed by the

G. A. Johnson
*of the Central Office Switching Development Department completed thirty years of Bell System service on November 8*

S. B. Williams
*of the Systems Development Department completed thirty-five years of Bell System service on November 15*

F. R. McMurry
*of the Apparatus Development Department completed thirty-five years of Bell System service on December 4*

Laboratories and was made available to the Associated Companies as the 221-A emergency radio-telephone equipment. The tests were witnessed by H. S. Sheppard, H. T. Friis, L. R. Lowry and S. B. Wright. Messrs. Sheppard, Lowry and Wright were luncheon guests of Colonel Olmstead, Commandant of Ft. Monmouth, and made a tour of inspection of the U. S. Army Signal Corps Laboratories and School at Ft. Monmouth. C. O. Bickelhaupt, Assistant Vice-President, V. B. Bagnall, Long Lines Radio Engineer of the A. T. & T. and other Long Lines people also took part in the activities.

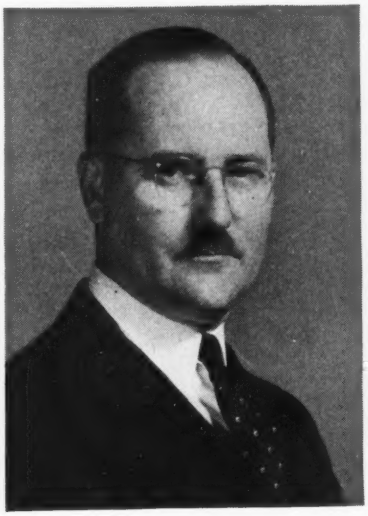
Field-strength surveys were made in Washington, D. C., by C. N. Anderson, A. L. Durkee and H. C. Foreman.

The board of overseers of Harvard College has recently appointed A. L. Whitman a member of the Visiting Committee covering the Harvard Graduate School of Engineering.

* * *

On the seventeenth of December, W. A. Knoop completed twenty-five years of service in the Western Electric Company and the Laboratories. In 1913 Mr. Knoop spent six months in the manufacturing organization of the Western Electric Company assembling train-dispatching selectors. He then spent two years at Pratt Institute, returning in 1915 to the Research Laboratory where he was first concerned with pumping and testing the vacuum tubes used in the Paris-Arlington-Honolulu radio demonstration. He then spent several years in vacuum-tube development work, in an investigation of the properties of vacuum tubes in oscillating circuits, and in a study of noise in vacuum tubes.

In 1926 Mr. Knoop transferred to the group concerned with the development of terminal equipment for submarine cable telegraph system. In this connection he spent some time in the



*W. A. Knoop*

*F. A. Bonomi*

Azores installing and testing the terminal equipment on the first permalloy loaded cable and then went to England on similar work connected with the cable that was laid to England by way of Newfoundland. Upon completion of this work he spent two years on the development of terminal equipment for the proposed transatlantic telephone cable. In 1932 Mr. Knoop transferred to the Television Research Department where he has since been engaged in the design and development of television terminal equipment. He was associated with the New York-Philadelphia television demonstration in which motion pictures were transmitted over coaxial cable. During this demonstration he was responsible for the production of the television signals which were then transmitted over the coaxial cable. At present Mr. Knoop is engaged in producing a video-signal generator to be used in further tests of coaxial cables. Thirty-nine U. S. patents issued under his name indicate his contributions to the communication industry.

* * *

F. A. Bonomi, who completed twenty-five years of service in the Western Electric Company and the Laboratories on the nineteenth of November, attended the Royal Naval University of Genoa, Italy, from which he received a B.S. degree. He also graduated from the Polytechnic Institute of Brooklyn in 1916 with an E.E. degree. Mr. Bonomi's first work with the Engineering Department of the Western Electric Company was in the apparatus design group during the early part of 1914. He then left the company for a short time and upon his return entered the Systems Development Department where he was concerned with the design of windings for the first punch-type relays used in manual and panel equipment.

From 1920 to 1932 Mr. Bonomi was engaged in the design and development of circuits for straightforward trunking and of various circuits for manual, private-branch exchange and machine switching systems. Since 1932 he has been concerned with ringing studies, crossbar-relay testing, and the design of relays and other apparatus to meet circuit conditions set up by the various design groups.

* * * * *

J. L. Merrill and R. W. Edmonds, with E. F. Smith of the Western Electric Company, assisted the New Jersey Bell Telephone Company in transmission tests made on the Newark subcenter of the weather-announcement system prior to cutting this subcenter into service.

*During the design and construction of the musa receiving system for the Long Lines installation at Manahawkin, New Jersey, weekly conferences were held by this group of engineers in the Radio Research Department. Left to right, George Rodwin, W. T. Wintringham, Frank A. Hubbard, F. A. Polkinghorn and E. J. Howard*

P. W. Blye, in collaboration with H. R. Huntley of the A. T. & T. Company and J. O'R. Coleman of the Edison Electric Institute, led a colloquium on *Physical and Inductive Coördination of Power and Telephone Systems* on November 27-28, at the Massachusetts Institute of Technology. Mr. Blye in his talk discussed recent developments in the noise-frequency coördination field.

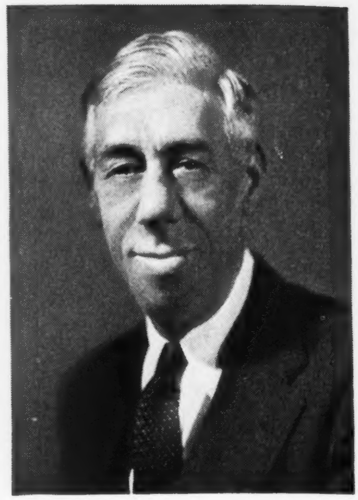
T. A. Taylor has been in Fayetteville, Arkansas, where he coöperated with representatives of the Southwestern Bell Telephone Company and the Rural Electrification Administration in a joint study of a noise-coördination problem.

J. Mallett has gone to Minneapolis to take part in further tests in the Stevens Point-Minneapolis coaxial cable.

J. H. Shuhart and C. H. Gorman, Jr., have gone to Little Rock, Arkansas, for high-frequency crosstalk tests on an open-wire line in connection

J. S. Garvin
*of the Apparatus Development Department completed thirty years of Bell System service on November 20*

G. P. Tromp
*of the Apparatus Development Department completed thirty years of Bell System service on November 29*



Frank Josberger
*of the Plant Department completed thirty years of service in the Bell System on November 29*

with the application of the type-J carrier system.

W. W. Sturdy, R. W. Gutshall and Miss E. M. Baldwin returned from a six months' field investigation of the dielectric strength of telephone aerial cables in the vicinity of Greenfield, Massachusetts. J. D. Maher and E. H. Gilson also assisted in this study.

The Laboratories were represented in interference proceedings by G. T. Morris before the Court of Customs and Patent Appeals, by R. J. Guenther before the Primary Examiner and by W. J. O'Neill before the Board of Appeals.

W. L. Dawson was at the Patent Office in connection with routine patent matters.

G. F. Heuerman made several trips to Philadelphia during November to attend the taking of testimony in interference proceedings.

E. B. Cave appeared before the Board of Appeals at the Patent Office in Washington relative to patent matters.

J. R. Townsend and W. J. Clarke, on November 10, addressed the Columbia University section of the American Institute of Chemical Engineers on *Application of Plastics to Telephone Apparatus*. Mr. Townsend discussed the engineering phases and Mr. Clarke the chemical aspects of modern synthetic materials.

Mr. Townsend spoke before a joint meeting of the Akron, Mansfield and Cleveland sections of the A.I.E.E. on the subject *High-Speed Motion Pictures and Their Application*. The meeting was held in Akron on November 14. Mr. Townsend also acted as technical chairman of a meeting that was held by the American Society for Metals at Columbia University.

C. H. Greenall, at the headquarters of the American Society for Testing Materials in Philadelphia, discussed matters pertaining to the coöperation of Committee B-5, devoted to cast and wrought copper and copper alloys, with various Federal Government Departments.

I. V. Williams, with R. Jongedyk of the Western Electric Company, Chicago, visited the Edgewater plant of the Aluminum Company of America in connection with the extrusion of aluminum condenser cans.

G. R. Gohn and L. W. Kelsay visited the Point Breeze plant of the Western Electric Company to discuss the manufacture of parts used in F-type terminals.

On November 28, K. G. Coutlee and W. Orvis were at the General Ceramics Company, Perth Amboy, New Jersey.

H. W. Evans and E. F. Vaage are engaged in making high-frequency tests on open-wire lines at Phoenixville.

D. K. Gannett attended the Fall Convention of the Institute of Radio Engineers at Rochester.

H. A. Etheridge and E. M. Staples were at Boston in connection with some tests on 20-cycle by-pass arrangements associated with the new two-wire telephone repeater.

H. A. Pidgeon and A. A. Heberlein visited the type-K carrier repeater office at Philadelphia in connection with vacuum tube matters.

R. D. Fracassi was at Chester and Long Valley, New Jersey, and at New London during November and December on matters pertaining to the use of thermistors to correct for temperature effects on transmission in toll cables.

AN ARTICLE ENTITLED *Line Problems in the Development of the 12-Channel Open-Wire Carrier System*, by L. M. Ilgenfritz, R. N. Hunter and A. L. Whitman, was published in the December issue of *Electrical Engineering*. This paper was presented before the South West District meeting of the A.I.E.E. last April. In the same issue is another article, *Some Applications of the Type-J Carrier System*, by L. C. Starbird and J. D. Mathis of the Southwestern Bell Telephone Company.

*Designing wiring and cable system of the musa receiving equipment for the Long Lines installation at Manahawkin, New Jersey. Left to right around the table: J. C. Gabriel, N. Lund, H. L. Holley, D. M. Black, A. Hartmann*

E. F. WATSON, with representatives of the Long Lines and O. & E. Departments, was in Schenectady on November 28 to discuss new arrangements for private-wire teletypewriter service designed for the General Electric Company.

THE NOVEMBER MEETING of the Metropolitan Chapter of the American Society of Safety Engineers was attended by R. L. Young, H. E. Crosby and L. E. Coon.

AN ARTICLE entitled *A Transmission System of Narrow Band-Width for Animated Line Images*, by A. M. Skellett, was published in the December issue of the *Journal of the Society of Motion Picture Engineers*. This paper was presented at the fall meeting of the Society, held in New York during September.

K. G. JANSKY's paper, *An Experimental Investigation of the Characteristics of Certain Types of Noise*, which was presented before a joint meeting of the International Scientific Radio Union and the Institute of Radio Engineers held in Washington, D. C., last April, was published in the *Proceedings of the I.R.E.* for December.

*Discussing mechanical design of the equipment of the musa receiving system for the Long Lines installation at Manahawkin, New Jersey. Left to right: A. A. Roetken, A. J. Munn, R. J. Kircher, N. J. Pierce, A. E. Harper and J. L. Mathison*

W. C. ELLIS spoke on *Metals in Communication Engineering* before the Connecticut section of the A.I.E.E. at a meeting held in Waterbury on December 12. That afternoon he also discussed the same subject with the graduate electrical engineering students at Yale University in New Haven.

E. C. MOLINA presented a talk to a Laboratories' group of night school engineering students on December 12. The subject of the talk was the adaptability of calculus to problems en-

countered in engineering and related fields.

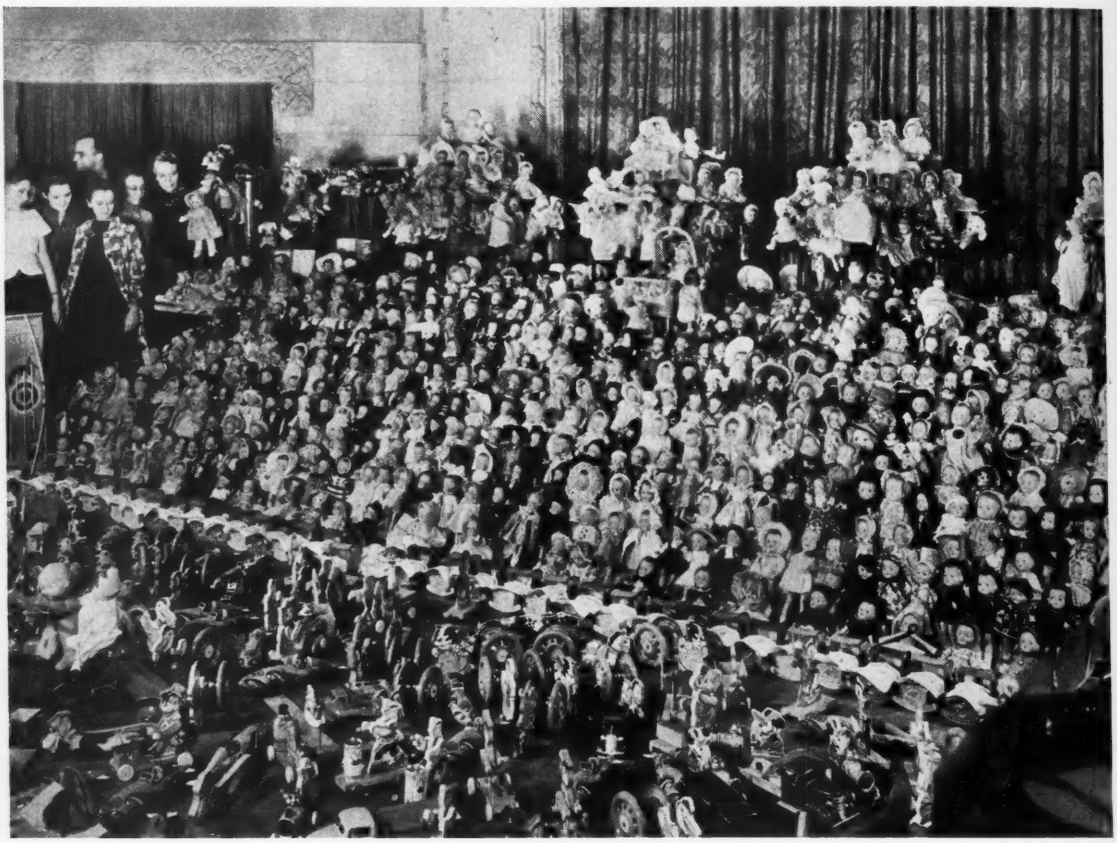
W. W. SCHORMANN attended the November meeting of the Personnel Club of New York at which Walter Dietz, Personnel Relations Manager of Western Electric Company's Manufacturing Department, spoke on *New Trends in Personnel Policies*.

R. J. HEFFNER represented the University of California at the celebration of the one-hundredth anniversary of the birth of Robert Henry Thurston, held at Cornell University on October 25.

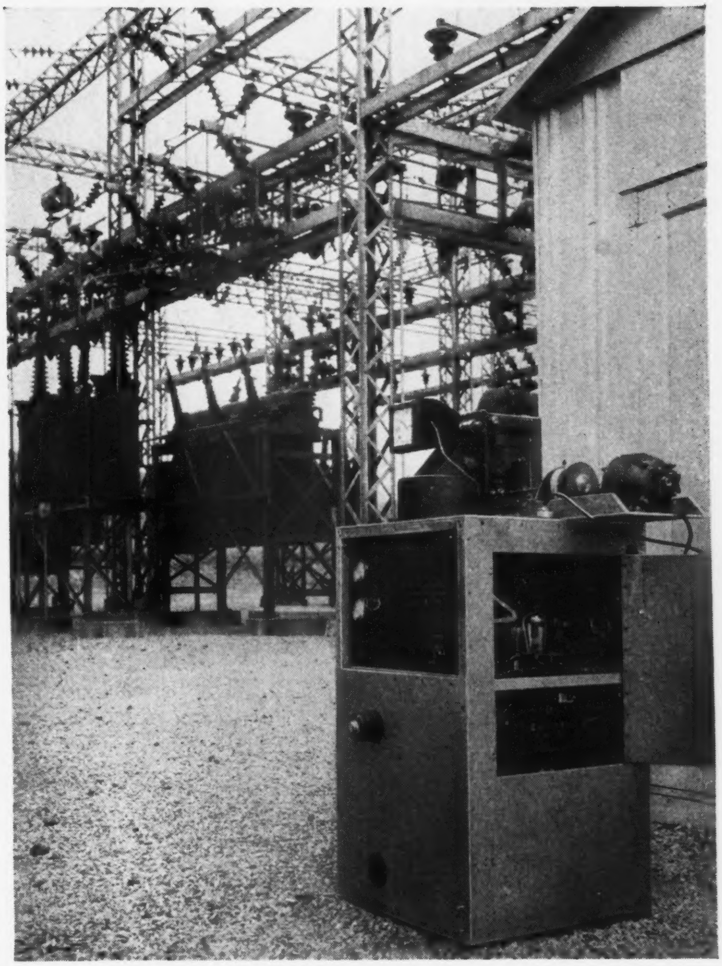
MISS RUTH E. EDDY attended a session of the Seventh Metropolitan Conference of the Welfare Council, held in New York City on November 17, which was devoted to a discussion of types of interviews and methods of improving interview techniques.

H. E. CURTIS and T. M. ODARENKO were in Baltimore for a few days in connection with transmission measurements on the coaxial cable being manufactured for the Stevens Point-Minneapolis installation.

THE EDITORS of the RECORD regret an error in the publication of the News Notes for November, 1939. The picture captioned with the name of Edward Sullivan was actually that of Eugene Sullivan, a former member of the Laboratories in the same department.



*Display of dolls and toys collected by members of the Laboratories in coöperation with a committee of women employees for children in hospitals, orphanages and other institutions in New York City, Bronx, Staten Island, Brooklyn and Long Island*



# Automatic Cathode-Ray Oscillograph

By W. L. GAINES
*Protection Development*

IN STUDYING transient currents in telephone circuits* and power systems, apparatus is required which will operate instantly and move quickly enough to record the initial part of the pulse. Oscillographs have been found suitable for this purpose. Usually they have been unattended and operated automatically by the disturbance to be recorded.

Until recently galvanometer-type instruments have been used. They were capable of recording only up to 3000 cycles and depended on film movement for wave-shape resolution. With instruments of this type a lamp must be lighted and the film started before recording begins. This takes at least a hundredth of a second, during which interval transients of importance may occur on the power system. Frequencies above 3000 cycles may also be involved. These deficiencies

*Page 140, *this issue.*

led to the search for a recorder capable of faster starting and of a greater frequency range.

An oscillograph with automatic features was chosen because it can record very high frequencies and requires only a few micro-seconds to release the beam. As developed by the Laboratories this oscillograph has, in addition to the cathode-ray tube, circuits which make the disturbance start the sweep action and the film movement. It also has power supplies and a photographic mechanism, including a lens system to project the trace from the screen of the cathode-ray tube to 35-mm motion picture film. The initial part of the record is made by sweeping the cathode-ray beam and during this interval the film

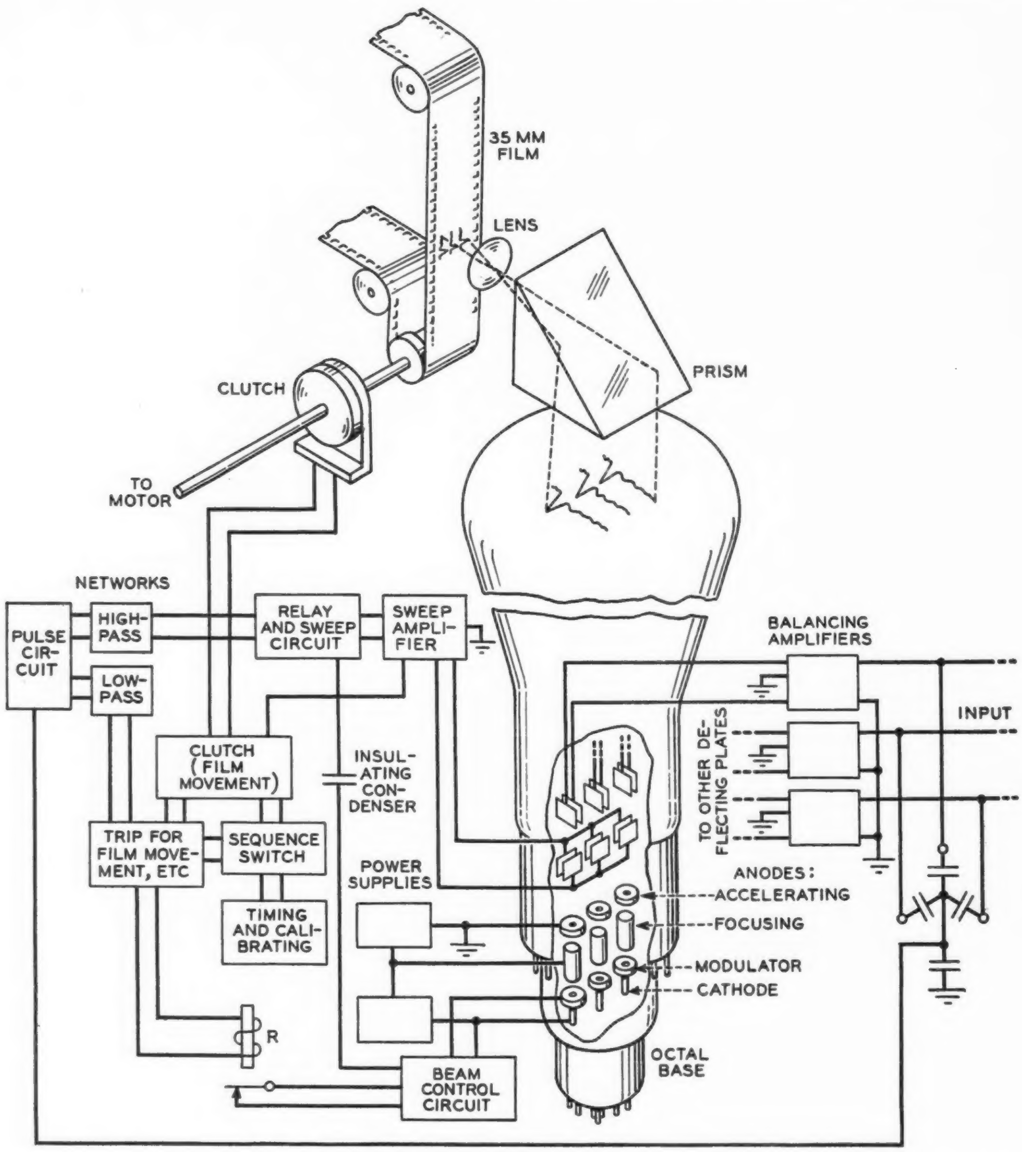



*Fig. 1—To investigate the effects of three-phase power lines, the line-to-ground voltage of each phase of the system was applied to one set of deflecting plates of a three-beam cathode-ray oscillograph. The motion of the images was recorded on 35-mm film*

starts to continue the recording. A complete record includes an automatic calibration and a clock picture to indicate the time the disturbance occurred. A schematic diagram of this oscillograph is given in Figure 1, with an outline of the circuits and a view of the photographic operating mechanism.

This apparatus was used in an investigation of overvoltages on a three-phase power system, conducted by the Joint Subcommittee on Development and Research of the Edison Electric Institute and the Bell System. Three recording elements were required, one for each phase, and this led to the choice of the Western Electric 330C cathode-ray tube, which is a development of the Laboratories. This tube has three complete units enclosed in a single glass envelope, thus making unnecessary three separate tubes with the attendant complication of the photographic system and increase in bulk. Each unit has a hot cathode, a modulator to control the magnitude of the beam current, a focusing electrode, and an accelerating electrode. The accelerating electrode imparts energy to the electrons and forms the beam, which strikes the screen where part of the energy is radiated as light. Two mutually perpendicular pairs of plates are provided for each unit. When a field is established between either pair of plates, the beam deflects toward the more positive one and the deflection is proportional to the amount of the applied voltage.*

*Fig. 2—The photographic mechanism of the oscillograph with the film magazine and clock are on top. The oscillograph tube is mounted in a metal cylinder, shown just below the clock, to protect it from stray magnetic fields*

The line-to-ground voltages of a three-phase system are applied to the deflecting plates through networks which provide a balanced input, because a well-focused beam is maintained only when the pair of plates is balanced with respect to the potential of the accelerating electrode. The other pair of plates in each group is connected to the sweep circuit to resolve the wave shape on the fluorescent screen.

*A single-element tube of the same type is described in the RECORD, *December*, 1937, *p.* 110.

The power supply for the cathode-ray tube consists of two cascaded rectifiers with smoothing circuits designed so that the effect of the current drain of the cathode-ray tube is negligible. As a safety precaution, this supply is entirely enclosed in a compartment and is so arranged that the plate voltages to the rectifiers are cut off and the condensers shorted if the door of the compartment is opened.

Voltage to trip the oscillograph is obtained from the drop across a condenser between ground and the neutral formed by three Y-connected condensers as illustrated at the right in Figure 1. The other terminal of each of these condensers is connected to one phase of the three-phase circuit under observation. When unbalance occurs on the power circuit, voltage appears across the condenser in the neutral. This voltage is fed to a rectifying circuit which converts it into unidirectional pulses thus assuring that the succeeding trip circuits will operate on incoming waves of any polarity. The pulses are fed through discriminating networks to two trip circuits, one of which is high speed and the other slower and sensitive only to low frequencies.

The relay which trips the high-speed circuit consists of two electrically interlocked vacuum tubes. A pulse of any frequency above 1000 cycles per second, of sufficient magnitude to operate this relay, excites the beam and sweeps it always at the same rate across the screen. By adjusting this high-speed relay and the sweep circuit the sweep speed may be varied in discrete steps in the ratio of approximately $\sqrt{2}:1$, from about 1/200 to 1/6000 of a second. This range of speeds was considered adequate because the transients of interest in this study were those which arise within the power system itself due to the faulting of a conductor rather than those impressed on the system by lightning. The output of the sweep circuit is fed to an amplifier which delivers a balanced output to the deflecting plates. A portion of this voltage is used to energize the clutch circuit by means of a cold-cathode tube and relay. This clutch-energizing

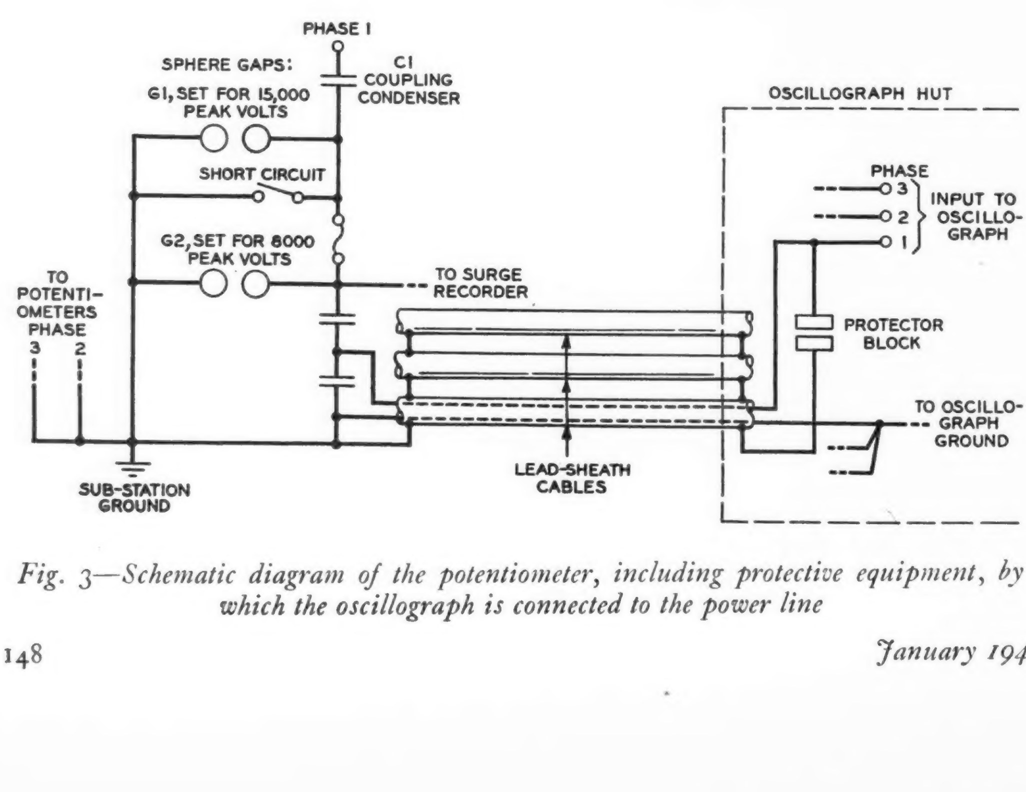



*Fig. 3—Schematic diagram of the potentiometer, including protective equipment, by which the oscillograph is connected to the power line*

circuit is self-resetting and, if the transient is short-lived, the clutch remains closed only long enough to give a film advance of about six inches so as to provide an unexposed piece of film for recording the next transient.

When the surge which trips the high-speed relay contains, or is followed by, power overvoltage a more extensive record is made. It includes the initial resolution by the sweep, about three seconds' resolution by film movement, a calibration and a clock picture. To obtain this additional record at the proper time, there was added a low-speed trip circuit, sensitive to sixty cycles and its lower harmonics. It consists of a cold-cathode tube and associated relays, which take control of the clutch and beam circuits and energize the sequence switch. The beam circuit is controlled by the insulated relay R (Figure 1) which actuates mechanically a contact, located in the high-voltage compartment, and keeps the beam active during the resolution of the record by film movement. The film movement initiated by the low-frequency trip circuit is terminated after a predetermined time by the sequence switch, which records on the film the calibration and a clock picture to show the time of operation. This film movement also resets the tripping circuit.

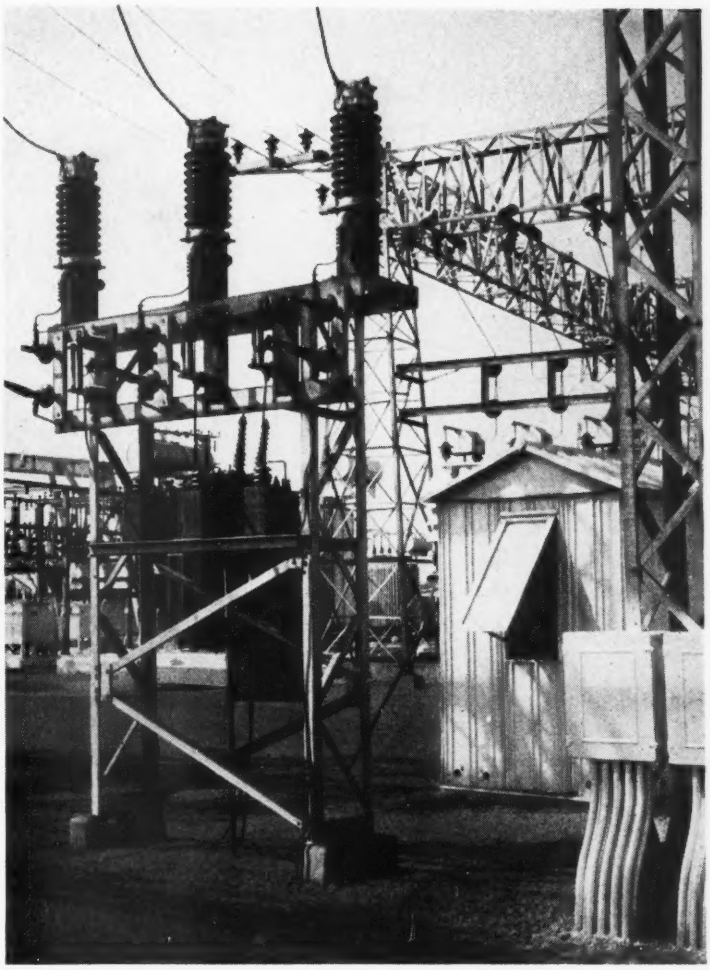


*Fig. 4—Capacitance potentiometer and protective equipment as installed between the power lines and the oscillograph*

Since the initiating transient of most power-system disturbances as well as those due to lightning contains higher frequency components, any disturbance will trip the relay and release the beams for the initial sweep, but a complete record will be made only when power-system overvoltage of fundamental frequency, or its lower harmonics, is present. Otherwise, the film only moves forward sufficiently to provide an unexposed section for a succeeding record.

The photographic system for recording the screen image is shown pictorially in Figure 1. The images on

the screen are recorded on 35-mm motion picture film. The cathode-ray tube and the optical system are oriented so that the beam's path across the screen will be recorded with the time axis longitudinally along the film. A clock picture can be made at the end of a record to indicate the time of the disturbance.

Figure 2 shows a picture of the oscillograph. The photographic mechanism is on the top with the film magazine near the rear left-hand corner and a clock projecting in front of it. The clock has two faces, one visible so that the operator can check the time and the other enclosed for photographing. At the right of the film magazine are the clutch and the motor which drives the film. The panel at the front of the instrument carries the meters and the trip sensitivity controls. The projection under the panel is the motor which operates the ventilating fan. All the control apparatus and the power supply equipment are contained within the case.

This oscillograph has been used to record phase-to-ground voltage on a 44-kilovolt transmission line. Capacity potentiometers, one for each phase, reduced this voltage to a value suitable for the oscillograph. The schematic diagram of the potentiometer and its associated protective equipment is shown in Figure 3. The protection equipment is designed so that gap G2 will break down if condenser C1 fails. The resultant current will open the fuse and gap G1 will ground the system until it is cleared by circuit breakers. Additional protection is furnished by protector blocks at the terminals and by grounding the oscillograph case.

The records obtained with the original sweep speed, which was fairly high, did not disclose any very high frequencies in the initial part of the disturbance on the power system under observation. Consequently the circuits were rearranged so that the resolution due to the sweep gradually merges with that from the film movement, thereby producing a continuous record. An example of the results obtained by this method is shown in Figure 5. Comparison with records of faults obtained with a string oscillograph shows that the cathode-ray oscillograph has effectively closed the gap of approximately one cycle required to start the string oscillograph.

In addition to the extensive data on overvoltages which have been obtained in this investigation, much experience has been gathered on problems met in adapting oscillographs for continuous automatic operation under routine field conditions.

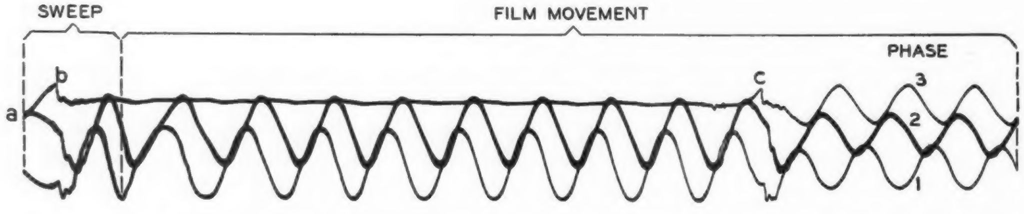



*Fig. 5—Oscillograph record showing a fault on one phase (Ph. 3) of a power line. The cathode beams are swept across the screen when the fault occurs to record the voltages on all three phases for approximately the first cycle while the film movement is starting. The rest of the record is obtained on the moving film. At (a) transient disturbance operates high-speed trip; (b) phase-to-ground fault develops—low-frequency trip operates; (c) breaker clears fault*


# Radio Compass for Small Vessels

By W. E. REICHLE
*Radio Development Department*

MARINE radio-telephone equipment is finding wide use in pleasure craft of various types. Although it is employed primarily for ordinary communication with shore, it has great potential value for summoning assistance in emergencies. Previously, only the larger vessels equipped with radio telegraph and manned by a commercial operator had such facilities. To increase the usefulness of Western Electric marine telephone equipment, the Laboratories recently developed the 50A radio-compass unit. When associated with the telephone equipment this unit will permit radio bearings to be taken to determine the ship's position.

The compass unit consists of a small metal box carrying tuning and volume controls on the front, and the loop antenna on the top. Power is obtained from the radio-telephone unit, and the loudspeaker of this unit is also employed. A jack is provided on the compass unit, however, to permit a headset to be used instead of the loudspeaker if desired. A switch on the telephone set switches these circuits to the regular antenna or to the compass as desired.

The 50A compass unit covers the frequency band from 230 to 350 kc, which includes all of the marine radio beacons maintained by the United States Lighthouse service at strategic points on the Atlantic, Pacific, and Gulf coasts, and on the Great Lakes. By taking bearings on two of such stations, a ship's position may be determined regardless of fog or darkness. Also included in the band from 230 to 350 kc are numerous aircraft beacon stations operated by the Civil Aeronautics Authority.

Operation is simple. On installation, the compass box is permanently fastened in position, and the bearing scale on the base of the loop, which is ad-

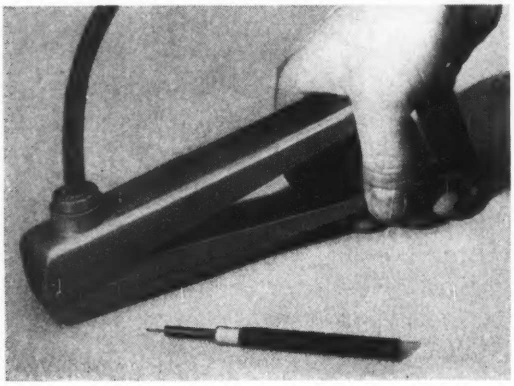
justable in position, is set so that the zero gives a direction in line with the keel of the vessel. After a signal has been tuned in, the loop is turned to the position of minimum signal. The reading of the scale then gives the bearing in degrees with respect to the ship's keel. The true bearing of the station may then be determined by the application of the ship's course as obtained from the magnetic compass.

The 50A compass was designed particularly for use with the 227B Radio-Telephone Equipment—a small radio-telephone set operating on either 6 or 12 volts dc and designed primarily for small vessels. Only minor modifications are required, however, to permit it to be used with either the 224* or the 226† types of radio-telephone equipments.

*Record, *June*, 1939, *p.* 358. †*Sept.*, 1939, *p.* 21.

## Crimping Tool for Coaxial Conductors

Indoor wiring of high-frequency systems, such as coaxial and radio, is done with coaxial conductors. This comprises a central copper wire, which is covered with heavy rubber insulation, and an outside concentric conductor of braided copper. The copper braid is protected with a single layer of cotton fabric. To finish the ends of this wire neatly, a metal ferrule is squeezed on with a special crimping tool designed and developed by H. C. Hey. The ferrule is a tinned cylinder of soft brass. Before it is put on the cable the fabric insulation and the braided copper are stripped back and a small metal eyelet is slipped between the rubber insulation and the copper braid. This protects the inner conductor from accidental short circuit by a strand of the braid which might puncture the rubber insulation.



In the crimping tool is a hollow metal cylinder of sixteen segments, tapered on the outside and extending about three-quarters of the length. This cylinder fits over the ferrule and over it fits another cylinder tapered on its inside. When the handles of the tool are squeezed the outer cylinder forces the segments of the inner cylinder against the ferrule and compresses it against the cable. A lip on the inner cylinder folds the inner end of the ferrule into the fabric and secures a rigid clamping. There are two holes provided in the ferrule by means of which it is soldered to the braid.

# Transpositions

By W. C. BABCOCK
*Transmission Development*

IN 1885, when a number of metallic circuits were provided on a pole line erected between New York and Philadelphia, a great deal of difficulty was experienced with crosstalk. A talker on one pair of wires could be overheard by a subscriber using any adjacent pair of wires. It was found, however, that this difficulty could be overcome by interchanging the relative positions of the wires of each pair at suitable points. This procedure is called transposing; and from that time on the design of transposition systems has been important in making possible long open-wire toll circuits.

The magnitude of the crosstalk* depends on the relative separation between the four wires forming the disturbed and the disturbing circuits. Transmission over the disturbing pair results in external magnetic and electric fields, which induce voltages in both wires of the disturbed pair. Because of the separation of the wires in this latter pair, a greater voltage is induced in one of them than in the other, so that there is a net voltage tending to cause a disturbing current to flow. When a transposition is introduced in one of the pairs, the direction of the disturbing current on one side of the transposition is opposite to that on the other side, so that there is a tendency for them to cancel each other. Because of the phase shift of the current as it passes along the line, however, there is never perfect cancellation. If, for example, the frequency of transmission is such that transpositions are a quarter wavelength apart, the disturbing currents

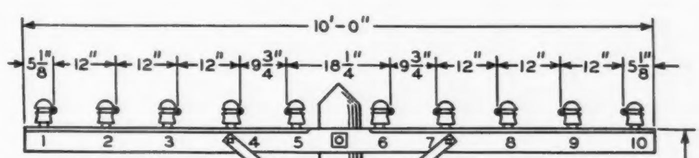



*Fig. 1—Configuration of conductors of an open-wire line*

*RECORD, *Nov.*, 1934, *p.* 66.

in the two segments adjacent to the transposition will assist each other, and the transposition will aggravate rather than improve the conditions.

For voice-frequency circuits, where the upper frequency is in the neighborhood of 3000 cycles, there is no difficulty in making the distance between transpositions short enough to give nearly complete cancellation in adjacent segments. Besides this factor, however, it is necessary to consider also the interaction of a large number of circuits on the same pole line. Figure 1 shows the cross-arm and pin arrangement that was long standard. Each arm carries ten wires or five pairs. The four outer wires on each arm are equally spaced, but the wires nearest the pole—comprising the pole pair—are spaced farther apart to allow a lineman to climb between them. With the large number of circuits that such a pole line might carry, the transpositions had to be arranged so as not always to appear at the same point on the pole line for adjacent or nearby circuits.

A study of the possible transposition schemes reveals the fundamental types or patterns of transpositions shown in Figure 2. This gives the different ways of transposing a pair of wires over a distance including thirty-two transposition poles. The distance between transpositions was originally taken as ten spans, each normally 130 feet, so that there was approximately a quarter of a mile between transpositions, and the length of the entire transposition section was eight miles. The various arrangements are desig-

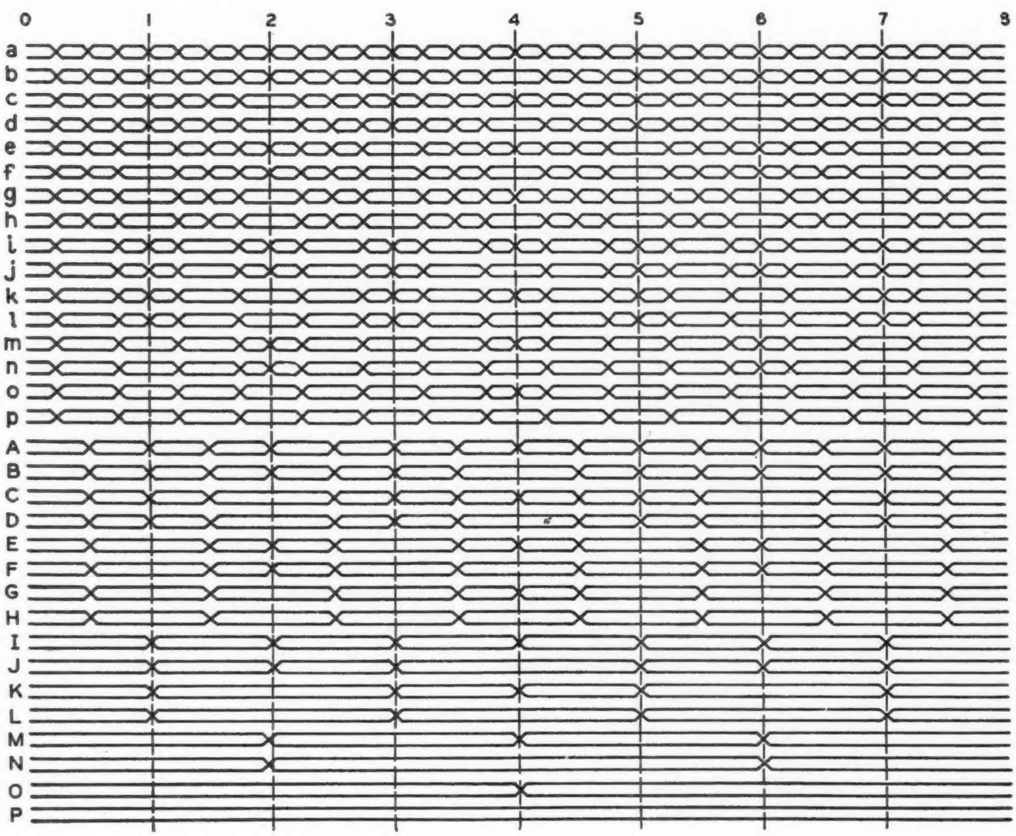



*Fig. 2—Fundamental types of transpositions requiring 31 transposition poles*

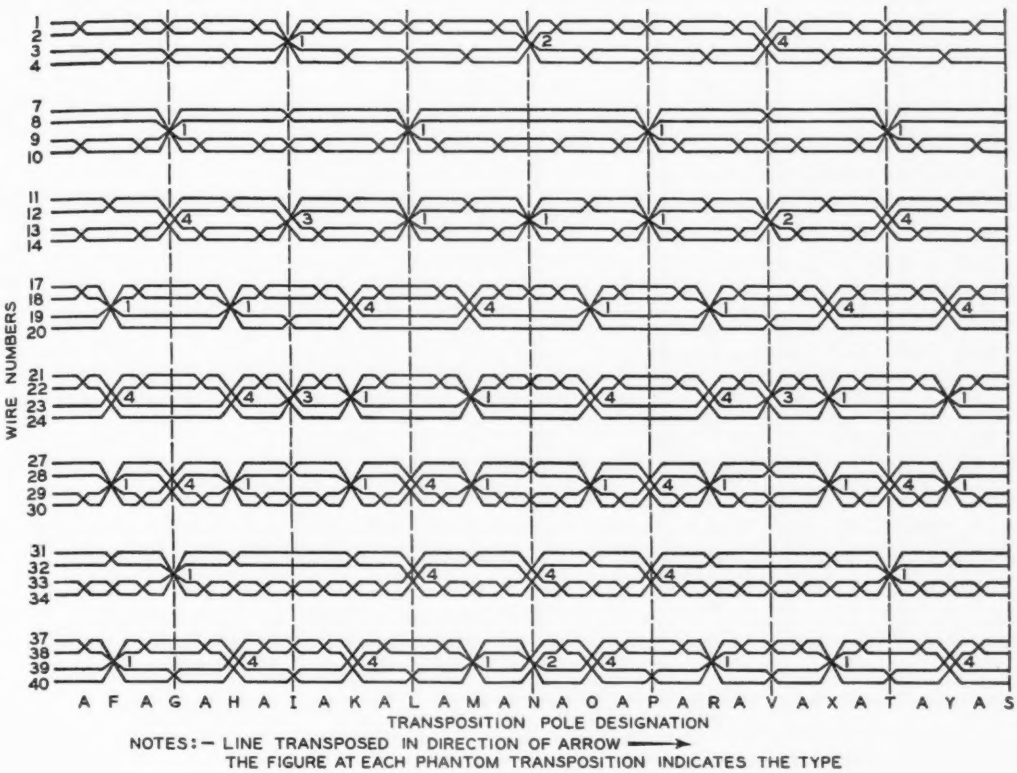



*Fig. 3—The "Standard" transposition system for four arms in an eight-mile section (Only non-pole pair groups are shown)*

nated by small and large letters from a to p and A to P inclusive. Selections were made from these possibilities to meet the requirements of various pole lines.

This eight-mile section was the longest used, and for long lines a number of sections were required. For a single complete section the crosstalk is small, and so when branch lines are required, it is desirable to drop them off at the end of a section. Where many branch lines were required, therefore, it was necessary to use shorter sections of various lengths so that lines could be dropped off at suitable points. The standard section, always used where possible for crosstalk reduction, is never so effective over several short dissimilar sections as it is over a single long section.

The situation was soon complicated by the introduction of the phantom circuit. Such a circuit uses the two wires of a pair as one of its conductors and the two wires of an adjacent pair as its other conductor. In this way a third, or phantom circuit, is provided for each two pairs of conductors on the pole line. The circuits which result from this phantoming are referred to as the "side" circuits. When such phantom circuits were superimposed on an existing set of transposed circuits, it was necessary to superimpose a set of phantom transpositions on the existing pair transpositions.

During these early years a large number of transposition arrangements were worked out by various people, for both pairs alone and for pairs and phantoms, and it was not until 1908

that the "Standard" transposition system was designed by O. B. Blackwell. This arrangement for thirty-two poles, each with four crossarms, is shown in Figure 3. This figure shows only the phantom groups obtained from the non-pole pairs of each arm, but arrangements were also provided for the pole pairs, and for infrequent odd combinations of pole pairs and non-pole pairs.

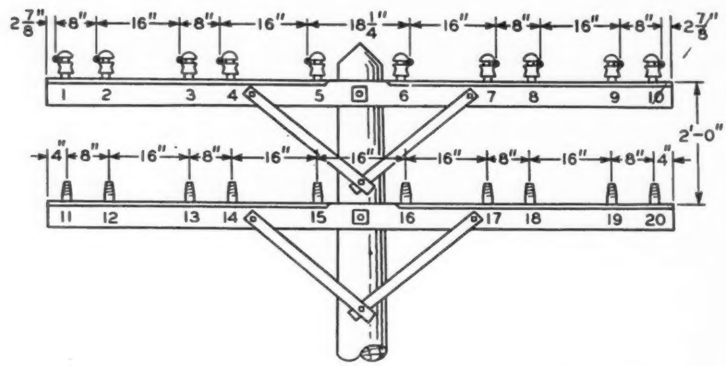



*Fig. 4—Configuration of conductors using eight-inch spacing*

Besides reducing crosstalk between circuits on the same pole line, transpositions also reduce the disturbances from outside sources, such as adjacent power lines. Where there was a severe exposure of this latter type, it was found that more transpositions were required than the Standard system provided, and in 1917 the "Exposed Line" system was designed. Later the "N" transposition system for exchange lines, where circuits drop off at frequent intervals, was designed. Only one transposition section was provided, but the transpositions were arranged so that no two pairs were untransposed with respect to each other for more than a short distance.

Shortly after the Exposed Line system was introduced, carrier systems were developed, and because of the higher frequencies, more transpositions were required. The type-C carrier system, for example, employs frequencies up to 30,000 cycles. At this frequency, the wave length is only one-tenth that at the top of the voice-frequency range, so that the requirement of holding the distance between transpositions to a small fraction of a wave length requires many transpositions. To simplify the transposition design, and thereby reduce its cost, several C carrier systems were designed with their frequency bands shifted somewhat with respect to each other. In this way the effects of crosstalk from one C system to another are reduced somewhat without any change at all in the transposition system. Additional transpositions were required, however, to reduce the crosstalk that still remained.

Since the transposition points had been ten spans apart, it was possible to introduce additional transpositions by transposing at every fifth pole as well as at every tenth. Such circuits were said to be transposed to single extra types. This did not prove adequate, and double extra types were employed. This required two additional transpositions between each two existing ones, and since ten spans cannot be divided into three equal parts, the two transpositions were put at the second and seventh poles. With such an arrangement, the crosstalk reduction is not so great as with uniform spacing.

Crosstalk induced in a circuit travels in both directions, that part going toward the same end of the line as the disturbing source being called near-end crosstalk, and that part

going on to the distant end, far-end crosstalk. The former, or near-end crosstalk, has the greater effect. Consider, for example, a section between two repeater stations, with voice being transmitted from west to east over one pair, which acts as the disturbing pair, and a conversation being carried on over the other, which becomes the disturbed pair. At the output of the west amplifier of the disturbing pair, the voice currents are at their maximum value because they have just been amplified. On the disturbed pair, the voice currents traveling from west to east have also just been amplified, while those going from east to west are at their low level because of the attenuation of the line from the east repeater station. The induced crosstalk is thus greater relative to the west-bound speech in the disturbed circuit than it is to the east-bound. As a result the near-end crosstalk has a greater effect and is more difficult to control than far-end crosstalk. For this reason carrier systems are not designed to transmit in both directions at the same frequency on the same pole line. The east-to-west band of frequencies, for example, is made different from west-to-east, so that near-end crosstalk is automatically eliminated. Without this provision no practicable transposition design could reduce the crosstalk to satisfactory values.

The first transposition arrangement for carrier systems was known as the "Alternate Arm" system. It was designed to permit type-C carrier systems on the side circuits of the end phantom groups of the first and third crossarms. The additional transpositions required were superimposed on the Standard or Exposed Line systems in so far as possible.

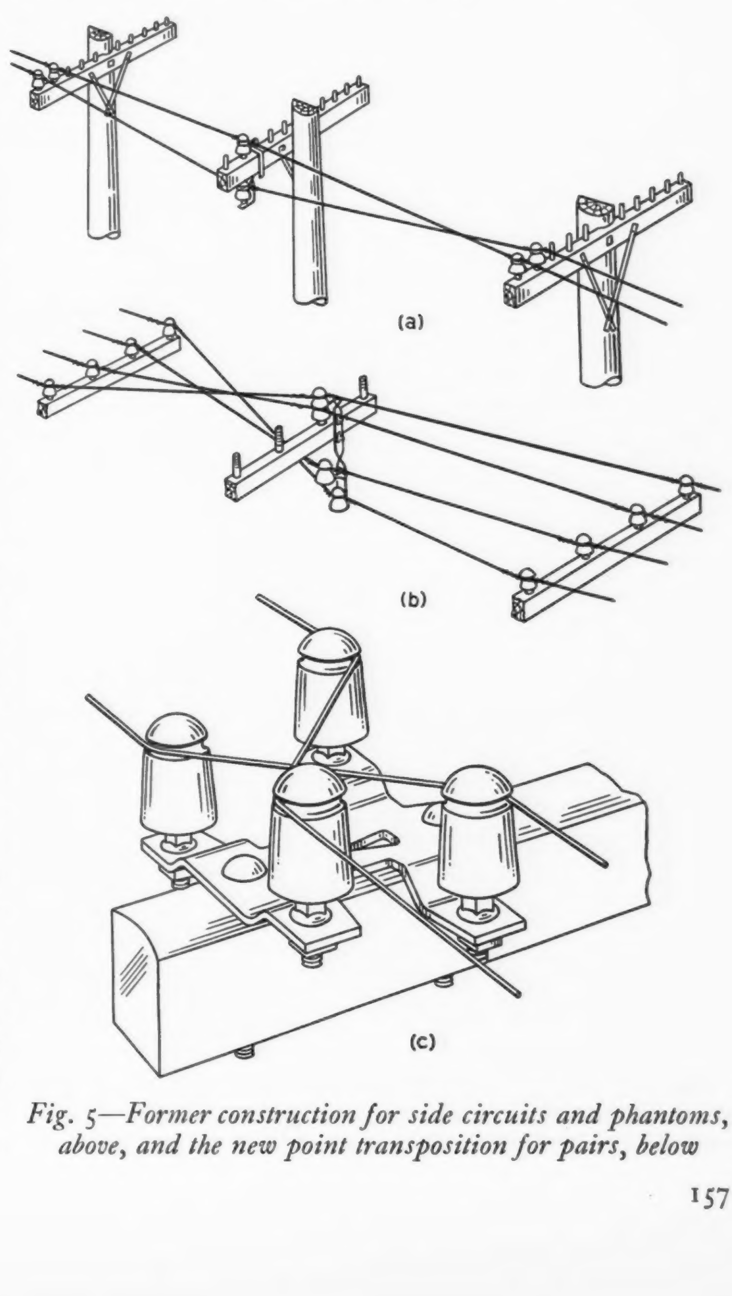



*Fig. 5—Former construction for side circuits and phantoms, above, and the new point transposition for pairs, below*

The "type-D" transposition system was next developed. It was designed for use with a single-channel carrier system having about 10,000 cycles as the top frequency. Crosstalk had to be controlled for circuit lengths only up to 200 miles, and single extra types were used on the side circuits of phantom groups. The type-D transpositions may be installed on Standard and Exposed Line transposition sections in one phantom group at a time without substantial modification of other circuits.

To permit more carrier circuits on a pole line and to facilitate greater crosstalk reduction than the Alternate Arm transposition system allowed, it was decided to discontinue the use of phantoms on all new toll lines except on the pole pairs, which are not used for carrier. In addition it was decided to use an eight-inch rather than a twelve-inch spacing for the two wires of a pair. The arrangement adopted is shown in Figure 4. Furthermore the spacing between transposition poles was changed from ten to eight spans so that triple extra transpositions could be used with equal spacing of all transposition points—the three transpositions being placed at the second, fourth and sixth poles.

With the reduction in wire spacing from twelve to eight inches, a new method of making the transposition was developed. Formerly a bracket carrying two insulators one above the other was employed at the transposition pole as shown in the upper part of Figure 5. For a phantom transposition a double bracket was used, as shown in the central sketch. With the new eight-inch spacing, the transposition was completely accomplished within a distance of a few inches at one pole by use of a new type of transposition bracket shown in the lower sketch. With the former method two spans were required for the transposition and the irregularities introduced in the wire spacing in these two spans proved to be a serious source of crosstalk. With the new "point" transposition, the very short distance within which the transposition is accomplished avoids this difficulty. Since phantoms will not be used for new carrier installations, no equivalent of the "point" system for phantoms is required.

Taking advantage of these modifications, a new transposition system known as the "K-8" was designed for application to all carrier systems on new lines. A new voice-frequency phantomed design was also prepared to coördinate with the K-8 design. Another transposition system, known as the "K-10" was designed to allow type-C carrier systems to be applied to all non-pole pairs on existing lines using the Standard or Exposed Line transposition systems. This kept the ten-span separation between main transposition points.

With the advent of the type-J carrier system having a top frequency in the neighborhood of 150,000 cycles, transposition engineers were faced with a five-fold increase in frequency as compared to the type-C system and with the possibility of reducing the spacing between transpositions to only one-half, since the K-8 system already used transpositions at every other pole, and extensive use of transpositions floating out in the span was considered impracticable. A new technique was required; but the manner in which this new problem was solved will be covered in another article.

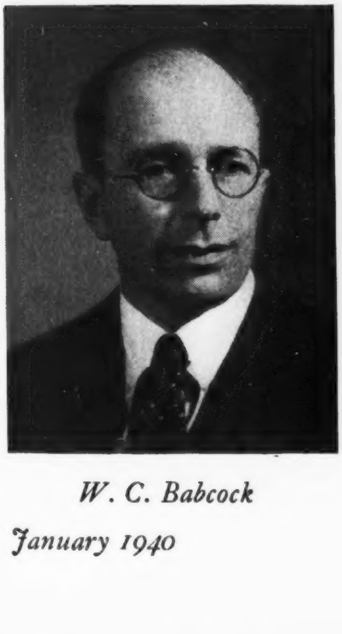
# Contributors to this Issue

W. C. Babcock received an A.B. degree from Harvard University in 1920 and a B.S. in Communication Engineering from the same university in 1922. He joined the Development and Research Department of the American Telephone and Telegraph Company in 1922, coming to the Bell Laboratories with that organization in the 1934 consolidation. His work has been largely on problems pertaining to crosstalk reduction in open-wire circuits in the Transmission Development Department.

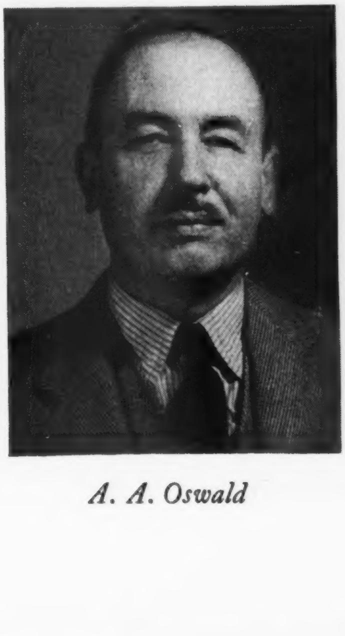
A. A. Oswald received from Armour Institute of Technology the B.S. degree in 1916 and the E.E. degree in 1927. With the Laboratories since 1916, he has been continuously engaged in its successive radio projects. He took part in the development of long-wave transatlantic telephony, and was at Montauk during early transmission experiments. During the World War he had charge of the field-testing of airplane telephones for the Signal Corps, and devised a method of radio control for airplanes in flight. From 1919 to 1922 he assisted in the development of ship-to-shore communication. Since then he has been concerned with the development of long-wave and short-wave transoceanic systems.

O. D. Grismore graduated from Purdue University in 1927 with the B.S. degree in Electrical Engineering, and at once joined the Development and Research Department of the American Telephone and Telegraph Company. Here his work consisted chiefly in the development, field installation and maintenance of recording instruments for inductive coördination studies. After the consolidation of the D. and R. with the Laboratories, he continued working along the same lines, but has recently transferred to a group building equipment for television measurements.

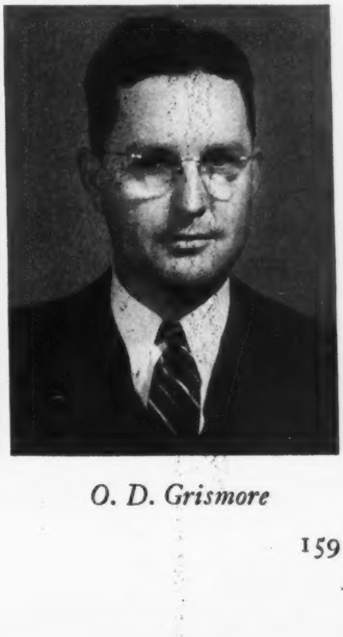
W. L. Gaines joined the Department of Development and Research of the American Telephone and Telegraph Company in 1926, coming from the Massachusetts Institute of Technology where he studied electrical engineering. For the first three and one-half years he was with a test group in West Virginia, working on



*W. C. Babcock*



*A. A. Oswald*



*O. D. Grismore*

*W. L. Gaines*

*W. E. Reichle*

*L. P. Bartheld*

inductive interference problems created by a railroad electrification. In 1934 he came to the Protection Development Department of the Bell Telephone Laboratories where he has continued work on low-frequency induction problems and the design and construction of special apparatus for protection development studies, especially cathode-ray oscillographs for use in measurements on power-transmission systems and in lightning studies on apparatus that is used in the communication plant.

W. E. Reichle received a B.S. degree in Electrical Engineering from the University of Michigan in 1928, and immediately joined the Technical Staff of Bell Laboratories. Here, with the Radio Development group, he has been engaged in the development of aircraft radio receivers for both beacon service and two-way communication.

L. P. Bartheld graduated from Iowa State College in 1921, receiving the degree of B.S. in Electrical Engineering, and immediately entered the Engineering Department of the Western Electric. Here he associated with the Systems Development Department and worked on the design of toll-switchboard equipment until 1929. Since that time he has been with the special equipment engineering group as a supervisor in charge of numerous trial installations. During this period he has also had charge of the systems department's participation and the installation of the Chicago, Dallas, San Francisco, and New York Fairs.